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THE ANATOMY OF A DOUBLE CALF.

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THE subject of this article is a Durham calf born near Minneapolis, Minn., in March, 1901. It lived only ten minutes; but excepting that there was a fracture in the hip bone no indication of injury was seen, and the different organs presented such a healthy appearance as to justify the belief that the calf could have been reared by taking special pains to that end. I owe the opportunity to examine the case to Mr. H. W. Howling, a taxidermist of Minneapolis, who sent me the carcass after the removal of the skin. I am indebted to Dr. C. Hart Merriam, Washington, D.C., for an introduction to the literature of teratology.

The appearance of the stuffed skin is shown in the two photographs, Figs. 1 and 2, views from behind and from the dorsal surface. There are two perfect anterior bodies, each with its head and thorax and the anterior part of the abdomen, and there are four perfect anterior limbs. The left body appears in the mounted condition (see Fig. 2) to be a complete body, into the side of which the anterior right half has been grafted at an angle of about ninety degrees. The hind legs stand nearly at

right angles with the axis of the left half, while they are nearly in the plane of the axis of the right. The internal structure, however, as will be seen, shows that in reality there are two nearly complete bodies strangely united to form the animal. Posteriorly the two bodies are united to form a single region, standing on a right and left hind leg, each of which belongs to one of the anterior halves of the body. There is a third hind leg. It does not touch the ground, but arises from the center

FIG. 1. — View of stuffed skin from behind, from a photograph.

of the rump and projects backward and to the left. This leg has the usual form and regions. Of course I have no means of knowing its bony structure, but it shows the same external subdivisions as the others and ends in two hoofs; the limb, however, is shorter than the others, as shown in this table of measurements.

	LEG.	FORE LEG.	FOOT.	HOOF.
Right hind leg	11 in.	8 in.	3 in.	1½ in.
Middle hind leg	6 in.	6 in.	3 in.	1½ in.

There are two tails, of the same form and size. They are symmetrical in position, each located between the functional hind leg of its own side and the middle leg. The anus is single; it is located directly under the median hind limb and equally distant from the tails. No indication of a urogenital opening was seen, and the structure of the bladder indicates that the penis had not been formed.

The coloration of the skin exhibits noticeable bilateral symmetry; the general ground color is brown, on which white spots,

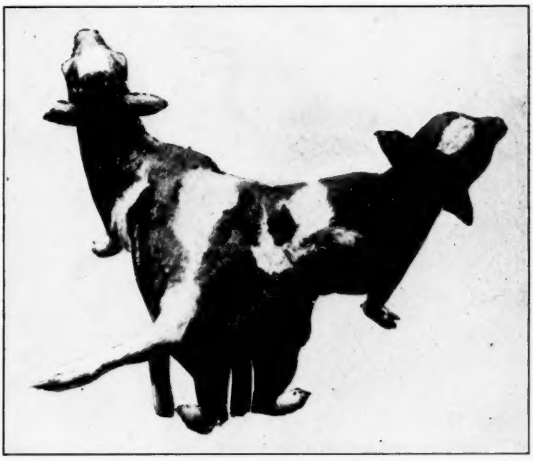

FIG. 2. — View of dorsal surface, from a photograph.

or areas, are found closely matching each other as to position and shape. On the top of each head is a white spot of much the same position, size, and shape; the two tails end in white, of the same length in each. The limbs are white below, except the inner fore limbs, both of which are brown to the carpal region, and the right to the toe in addition. A girdle of white encircles the body of each; it is more solid on the left side. There is a patch on the loin region of each. The following measurements were made from the mounted animal:

Height of body at hip . . .	27 in.	Length of right tail	13 in.
Base of tail to tip of right nose	35 in.	" left "	13 in.
" " " left "	35 in.		

The body as it reached my hand had the skin removed, and the heads and lower limbs. The external points noticed were these: There was a single anus; a single median umbilical opening was present; there were two bilaterally placed testes located on the wall; they had passed to the surface but no scrotum was formed; they were somewhat widely apart (four inches?); a penis was not present. There are two complete spinal columns, as would be inferred from the presence of two

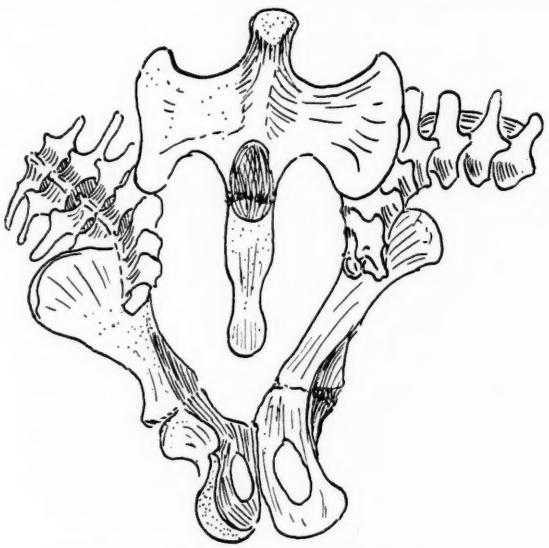

FIG. 3. — Dorsal aspect of the bones of the sacral region.

tails. They are, however, both considerably modified in and behind the lumbar region, as shown in Figs. 3 and 4, which are dorsal and ventral views of the osteological preparation of that region. Both columns are evidently present; they come toward each other and then bend into parallelism, the right becoming concave on the right side, and the left on the left side. This is brought about by the outside of each vertebra being considerably smaller than the inside. The transverse processes of the lumbar vertebræ are not much more than half as large on the outside of the vertebra as they are on the opposite

side. The sacral vertebræ are not only bent as described but there is a twist in them so that the centra come to face inwards, and instead of looking downward they look toward each other. Each sacrum articulates on its outer side with an os innominatum of the usual form, consisting of ilium ischium and pubis, meeting to participate in the formation of an acetabulum for the reception of the femur of the paired leg of its own side of the body. The pubic bones meet ventrally and form a normal

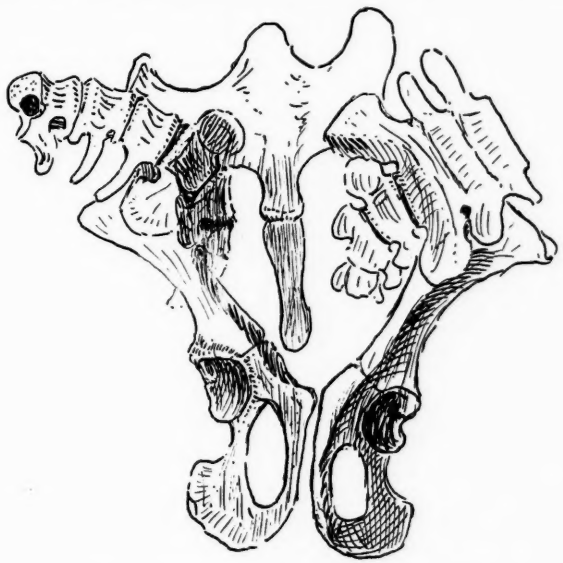

FIG. 4. — Ventral aspect of the bones of the sacral region.

symphysis pubis. The two sacra articulate internally with a peculiar bone, evidently composed of two incomplete ilia. This bone presents anteriorly two crests, each with the usual relation to the corresponding sacrum. In the center of this median bone there is a ridge which ends bluntly in front, and posteriorly meets a broad, thin, and somewhat tapering bone by a distinct suture. At the junction of these two parts is situated a shallow but distinct articular surface; it is the acetabulum of the median hind leg. It is very evident that the anterior bone

is composed of parts of two ilia incompletely separated, and that the hinder bone is in like manner made up of the parts of two still less developed ischia, while no traces of the pubes have appeared.

No dissections of the muscular or nervous systems were made, but we can infer from the osteology that there were two complete spinal cords. The innervation of each of the two functional hind legs must have been from the spinal cord of its own side. This separateness of the cord would have seriously affected coördination. It is related that in the two-headed turtle locomotion was very imperfect (Barbour, '96), and in Ritta-Christina (Hektoen and Riesman, '01) a pinch on the right leg was felt only by Ritta and one on the left only by Christina. The indications from a study of the bones are that the musculature of the outer legs was complete, while the muscles and nerves of the inner side must have been partly, though very incompletely, developed.

The viscera of the thorax were not examined. This is to be regretted, because it would have been important to determine whether the two hearts and vascular systems were counterparts. It seems likely from the anatomy of the animal, so far as known, that they were; still, I am unable to assert the fact. There were two complete diaphragms, and the abdominal cavity was

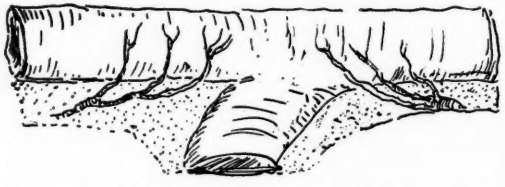

FIG. 5. — Junction of the small intestines of the two anterior bodies, and origin of the single posterior small intestine.

completely subdivided anteriorly. The two livers were entirely distinct, as were also the two stomachs and the upper parts of the intestines. The small intestines run toward each other and meet, forming a continuous tube, as is shown in Fig. 5. There is no indication of a union of two parts at this junction. The vascular supplies of each part are totally distinct, the vessels of

each side running out to reach the common territory. The distance from this junction to the anus is seven feet and two inches, in all of which the intestine is single. The single small intestine arises obliquely out of the common passage, and not, as might be expected, squarely from it. After running a distance of three feet, the small intestine dilates to form the large intestine. Here two cæca of unequal size are located. The two cæca are exactly opposite each other, and their cavities are continuous. At their junction they open together into the intestine at the beginning of the large intestine. The large intestine runs directly to the single anus, a distance of four feet and two inches.

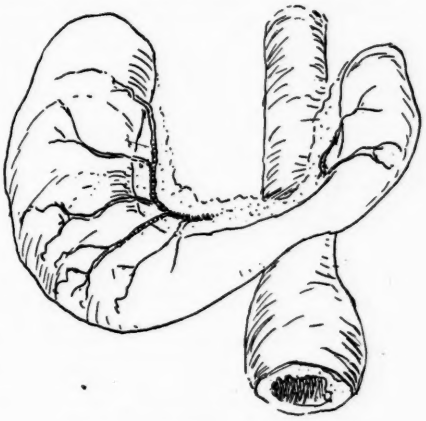

FIG. 6. — The two cæca at the junction of the small and large intestines.

There is normally in the calf only a single cæcum. The presence of two, then, is due to contributions being present from each of the component bodies of the animal. The single intestine could be interpreted in either of two ways, *viz.*, that there was a single intestine into which that of the other half had been engrafted not far from the stomachs, or that the intestine is really parts of two fused in the middle line and thus forming one. The oblique insertion of the single intestine at its origin seems at first to favor the first view, but there is considerable evidence against it. Dr. Wyman ('66), in the case of a double human embryo which he dissected, found that the intestines meet in the middle line and fuse to form a single tube, which, however, soon parts, forming two which run side by side for a time, after which they unite in a single rectum and terminate in a single anus. The presence of the two cæca in the case before us indicates that parts of two intestines, each

running the entire length of the half body to which it belongs, meet in the middle line to form one tube. This mode of origin is in harmony with that seen in the inner iliac and ischial bones and the median hind leg.

The vascular system shows a similar arrangement. Anteriorly there are two complete systems, while posteriorly the systems are complete on the outside, but not entirely so in the central

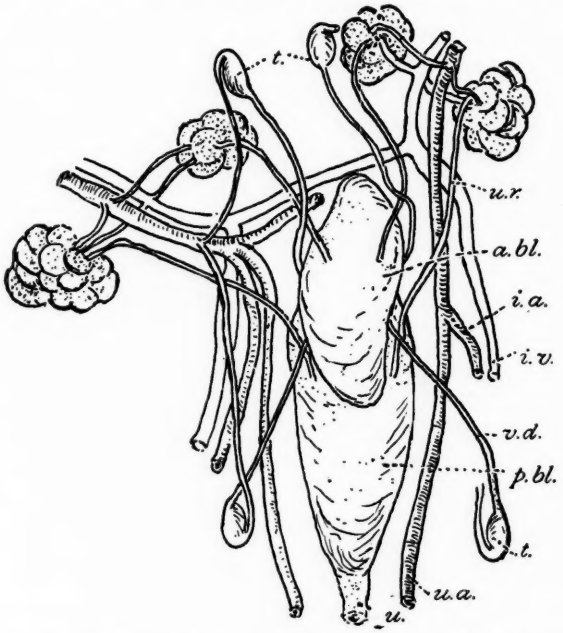

FIG. 7.— The urogenital organs and related blood vessels: *a.bl.*, anterior bladder; *p.bl.*, posterior bladder; *u.*, urachus; *ur.*, ureter; *u.a.*, umbilical artery; *i.a.*, iliac artery; *i.v.*, iliac vein; *t.*, testis; *v.d.*, vas deferens.

area. There are two dorsal aortæ (Fig. 7), and the renal and spermatic arteries are in pairs on both sides, as if the bodies were independent. Posteriorly, however, the aortæ each give rise to one large iliac artery to go to the paired leg of that side, and a second which was not traced beyond the root, where it soon disappeared among the muscles. At the fork of these iliacs a single umbilical artery arises from each aorta; it runs

down alongside of the bladder and, passing out with the urachus, runs to the placenta. A second umbilical artery for each would be needed to complete two entire bodies; these are wholly wanting. There are two posterior venæ cavæ, one for each body half, and similar renal veins were recognized. Posteriorly

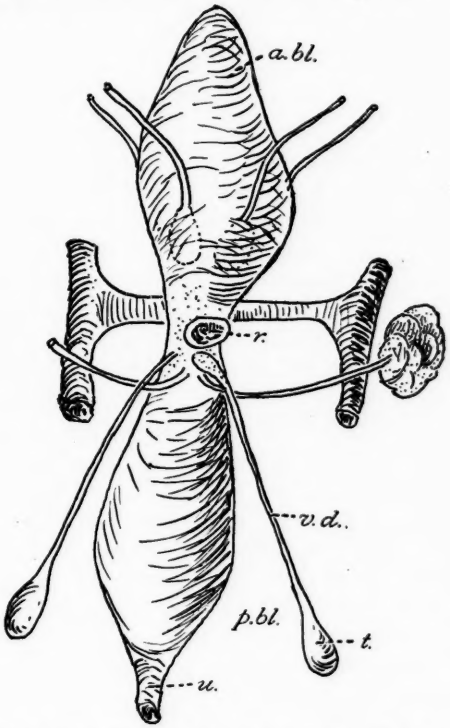

FIG. 8. — The two bladders and related ducts. The anterior bladder has been folded over forward so as to show the anterior surface of the posterior bladder: *r.*, rectum; the other letters as in Fig. 7.

the venæ cavæ divide and give rise, after the manner of the aorta, to an iliac vein for each of the two paired hind legs. But the inner iliac veins run toward each other and meet and fuse, forming a single large communicating iliac vein, thus extending the list of posterior parts common to the two body halves.

There are four complete and independent kidneys; two, by their position and vascular relations, are clearly indicated as belonging to each component body. The kidneys are compound, after the form general in ruminants; each has its hilus looking toward the dorsal aorta, at which three vessels enter its substance, *viz.*, the renal artery, the renal vein, and the ureter. There are two bladders; both are median in position, and one is located in front of the other. They may be designated as the anterior and posterior bladders. They both spring from a common neck, where they are attached indirectly, in common with the end of the rectum, to the body wall. At this place they partly surround the end of the rectum. They are in open communication at the neck by a passage running on the right side of the rectum; but in this region, where the urethra should appear, none is present, and there is no communication here with the exterior. No indications of a penis were found. The posterior bladder had an open urachus whereby it could discharge, but the anterior lacked this entirely, and drained through the passage at the neck into the posterior bladder. The relations of these two bladders is such that the posterior bladder receives the ureters from the two outer kidneys, while the anterior bladder receives those of the inner pair. The ureters of the posterior bladder run down and open into its anterior or dorsal surface, as shown in Fig. 8, and in doing this are aberrant, it being the opposite side to that general in mammals. The anterior pair of ureters are similarly aberrant. Two views are possible with reference to these bladders: either they may be considered as belonging one to each of the two component bodies, in which case we should be obliged to consider that they had, unlike most of the organs of the compound, taken a non-homologous and unsymmetrical position; or else they may be regarded as a single formation common to the two bodies, comparable with the hinder part of the intestine, which has been secondarily subdivided. The latter view seems perhaps more in harmony with the rest of the construction of the body, but decisive evidence cannot be had from the materials furnished in the dissection.

The genital organs show the same relations as the renal system. There are four testes: two are related to the two kidneys of one body and the other two to those of the other. These four testes are, however, paired in the calf not with reference to their individual bodies, but with reference to the compound. Two, as already mentioned, have descended: they are the right of the right body and the left of the left; we may call them the two outer testes. The two inner testes also carry out the symmetry, both remaining in their primitive position beside the kidney. These testes all reach the exterior by means of ducts which have the same relation as do those of the corresponding kidney. Those of the outer testes cross the ureters from the outer kidneys and enter a glandular mass (seminal vesicles?) in the wall of the posterior bladder. The two inner vasa deferentia run down and attach to the anterior bladder, passing as normally to the posterior surface.

The entire urogenital system thus follows the same law of symmetry of the homologous parts as we have seen in the other systems of the animal. This is the more interesting in this case, for in regulating the relations of the ducts from the organs the law comes into conflict with the symmetries of the two individuals and replaces it. This is evidence of the presence of a deeper law of regulation, and indicates the "fission theory" (Hektoen and Riesman, '01) of origin for the monster rather than the "union theory."

The limits of this article do not permit an extensive notice of the literature of teratology; a list of writers consulted is given at the close. Dr. Fisher ('66) gives a figure of a calf much like this one externally, — a case of "diplocephalus tetrabrachius tripus," — but the supplementary hind foot is ventral and anterior, indicating a difference in the mode of union of the pelvic bones. No account of the anatomy is given. He mentions that it was dissected by Dr. Wyman, but I have not been able to get any information of that dissection or its results. The case belongs in the line of double formations, which begins at the minimum with doubling of digits, runs through every stage of double formation of hands, arms, and other parts, of whole regions (as the head and trunk),

and finally culminates in twins: either incompletely separated, as the Siamese twins, or completely separated as in ordinary cases. Authorities in the main assign all such cases to a "division of the ovum imperfectly effected," so that "the resulting bodies instead of becoming complete twins remain united together, frequently having a greater or less extent of the body in common"; thus Bateson ('**94**): "Double formations arise from a fission of the whole or a part of the original embryonic mass." There are two theories as to the process: "one holds that they arise by splitting of the original germinal area of one embryo, and the other that they arise from the fusion more or less of two distinct embryonic areas lying in one ovum" (Hektoen and Riesman, '**01**, p. 419 *et seq.*). The present case indicates a partial fission of the germinal material, that destined to give rise to the anterior parts being wholly divided, while some of that destined for some of the hinder organs remains undivided. This case comes between the Tocci brothers and the Siamese twins. The former of these I have seen, and Fig. 9 is from a photograph of them. In these the hinder part of the body is apparently strictly single; there is less division than in the calf specimen. The Siamese twins were essentially double throughout. In the calf the hind part of the body is incompletely double. There are cases very nearly like it, of which a brief mention will be interesting. The Hungarian sisters, Helen and Judith, had one vertebral column as far forward as the second sacral vertebra; there was a single anus and rectum; both felt the same desire to defecate; there was a single vulva but separate urogenital systems; they urinated separately by different urethra; menstruation came at different periods in each (Hektoen and Riesman, p. 430).

In the case of Ritta-Christina the following items are noted from the account in Gould and Pyle ('**97**, p. 185): umbilical cord and placenta single; heads, necks, arms, and thorax above double; abdomen single; lungs imperfectly double, the central lungs being underdeveloped; one pericardium but two hearts; hearts synchronous; digestive organs separate as far as lower third of ileum, then single to the anus; stomachs, spleen, etc., were right and left; livers right and left were

fused centrally; there were two gall bladders beside each other in the middle line; the uterus was double; the vertebral columns were entire and separated by a mass of bone consisting of fused rudimentary ossa innominata; the sterna were united at their manubria. Reference has been made in an earlier part of this paper to the case of a human fetus dissected by Dr. Jeffries Wyman ('66). It was less double than the calf. There were only three arms, the median one made up of two halves fused; a single pericardium enclosing two hearts; a single lower vena cava branching anteriorly to enter each heart; the umbilical cord had one vein and two arteries. The right and left duodenums came together a short distance from the two stomachs, whose pyloric ends were turned toward each other ("symmetrical counterparts," Bateson, p. 559), but afterward separated and, though side by side, continued distinct nearly to the cæcum, which, as well as the large intestine, was single. There was a single urinary bladder with a double cavity. There were only two kidneys, but they were compound, and each had two ureters,

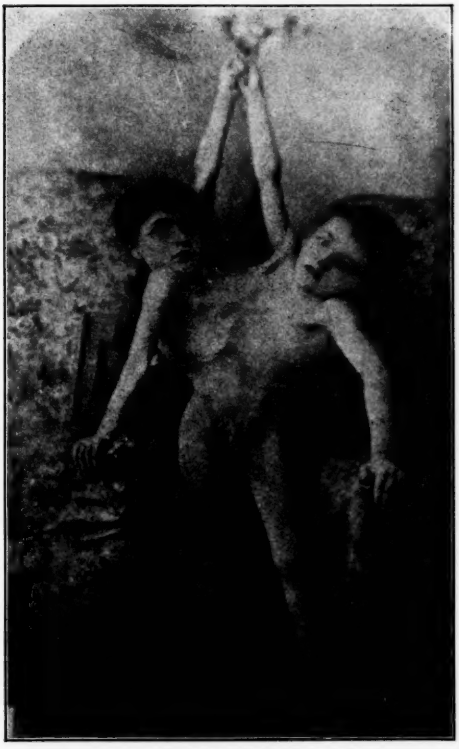

FIG. 9.—The Tocci brothers, from a photograph in possession of the writer.

one set opening into the upper bladder and a second, much larger, opening into the lower bladder. The bladders had the usual shape, but inwardly the mucous membrane formed a partial partition, near which the two sets of ureters opened. There were also two pairs of testes, one of which were resting on or quite near the kidneys and the other had descended and were "just at the entrance of the inner abdominal ring."[1] This case is much like that of the calf, — the union of the two intestines, the four ureters, and the two bladders, one in front of the other; it is not clear that the outer pair opened into the hinder bladder, but that seems to be intended. The account of the anatomy of the kidneys leaves somewhat to be desired; apparently the fission of the embryonic material had not gone so far here as in the calf specimen as to the kidneys, while it had as to the ducts. The relation of the testes and the ducts seems to have been about the same as in the calf.

Biological Laboratory, Hamline University,
Saint Paul, Minn., April 2, 1902.

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[1] Partly quoted and partly condensed from Wyman's paper.

THE METAMORPHOSIS OF SISYRA.

MAUDE H. ANTHONY.

SISYRA, like most of the Hemerobiidæ, is an insect of whose life history no thorough study has been made, and very little is known of either its habits or metamorphosis. It is an obscure little fly, chiefly interesting on account of some peculiar structures of its larva. The larva has been known since Westwood described it in 1839, but it has never been reared until last summer, at the entomological field station at Saranac Inn, New York. It passes its larval existence as a parasite on fresh-water sponges, clinging to their surfaces or descending into the open osteoles, piercing the sponge tissue with its long decurved jaws. The food thus obtained is so pure as to be wholly absorbed, leaving no residuum. At least one-fourth of the posterior portion of the stomach is atrophied, leaving no opening from the stomach at that end. Carnivorous habits and piercing mouth parts are common to other hemerobian larvæ, but the decurved position of the mouth parts and the tracheal gills are peculiar alone to this insect and Climacia, its nearest ally, which is of similar habits. The singular adaptations of the mouth parts and alimentary tract to the nature of its food I shall describe in detail in this paper.

The most remarkable structure of this larva is the silk-secreting apparatus. In general the silk glands of insects are metamorphosed salivary glands, but in the Sisyra larva they are a modification of the Malpighian tubules; and it seems probable that the nitrogen waste of the body is used, partially at least, in the manufacture of silk. This seems to be another remarkable instance of the economy of the by-product occurring in insect life. No such extensive modification of structure in adaptation to a peculiar environment has been described in any other insect; but two near relatives of Sisyra, Osmylus and Myrmeleon, have a somewhat similar development of silk glands.

The species which I have studied for this paper is *Sisyra umbrata* Needham, and all my specimens were collected for me, a few at Lake Forest and the remainder at Saranac Inn. I have necessarily worked under limitations, not having myself seen any living specimens.

The adult (Fig. 1) is a smoky brown fly, 6–8 mm. long, very hairy, and with the characteristic venation of the Hemerobiidæ, although the wings are not so delicate and transparent as are those of the lacewing flies. The maxilla and labium of the adult, each with peculiar pediform, terminal, palpal joints, are

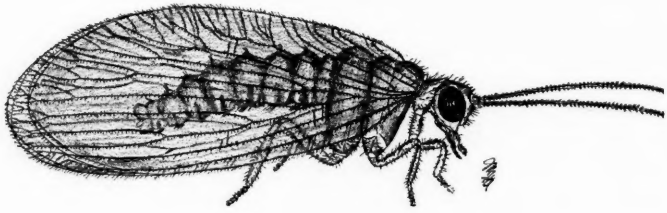

FIG. 1. — *Sisyra umbrata*, adult. × 10.

shown in Fig. 2. Other parts of the imago — antenna, leg, and wing — are figured and discussed later, in comparison with the same parts in the larva.

The pupa, removed from its double cocoon of finely woven silk, is shown in Fig. 3. It is 4 mm. in length, has two clusters of hairs on the dorsal surface of each segment, and is similar to the larva in color and marking, except that the light median line on the dorsal surface between two dark ones, so apparent in the larva, is not visible. Instead the brown crescent-shaped markings on either side meet in a dark median line.

LARVA — EXTERNAL ANATOMY.

The larva (Fig. 4) is 6 mm. in length, is yellowish green in color, and has quite a distinct color pattern in brown on the dorsal surface. Each of the first seven segments bears, in two dorsal and two lateral groups, twelve projections, except the first abdominal, which has only four on the dorsal surface

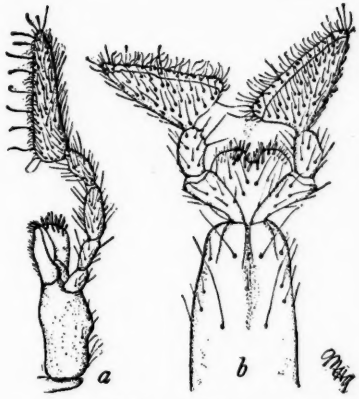

FIG. 2. — Mouth parts of adult. *a*, maxilla, × 60; *b*, labium.

but six on the lateral. Each of these is provided with a long hair. Their purpose seems to be for protection, as the floating particles retained in them make the insect look very much like a diminutive piece of aquatic vegetation. The same thing is described by Kent for Hemerobius, where the protection is furnished by the dead bodies of its victims, the aphids which are held by the long hairs. On the seventh and eighth abdominal segments there is an additional pair of hairs on shorter pedicels, near the median line. On the eighth segment there are two dorsal and two lateral projections, more elongate than those of the other segments, each of which serves as a pedicel for three hairs. The ninth has only the lateral projections. The tenth segment is everted at the end to serve as a spinneret for ejecting the silk. In sections the chitin on this part is noticeably thinner than that covering the rest of the body. Between the head and prothorax on the dorsal side is a small interpolated sclerite, mentioned by Grube, and also by Hagen in his description of Osmylus. There is no trace of it, however, on the ventral side. In Chauliodes, an insect which has the mouth parts normally directed upward rather than downward, as is the case with

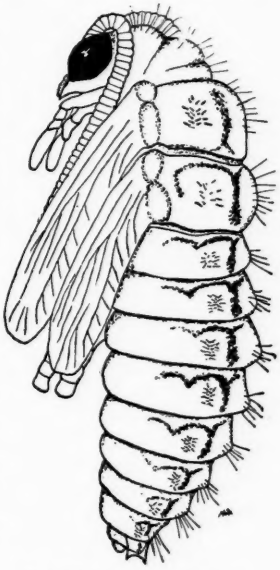

FIG. 3. — *Sisyra umbrata*, pupa. × 21.

Sisyra, there is an interpolated sclerite on the ventral side. The head has on the dorsal surface a pair of hairs directed forward, and on the ventral surface another pair similarly directed but much more elongate.

The larval respiratory apparatus consists of external gills in the form of a pair of jointed appendages on the ventral surface of the first seven abdominal segments, folded under the body so as to be unnoticeable in a dorsal view. They are moved intermittently in a rapid, shuttle-like vibration. Westwood has figured them with five joints, but I have found them uniformly to have only three. The first pair seem to have lost the articulation between the first and second joints. These have thus become two-jointed appendages.

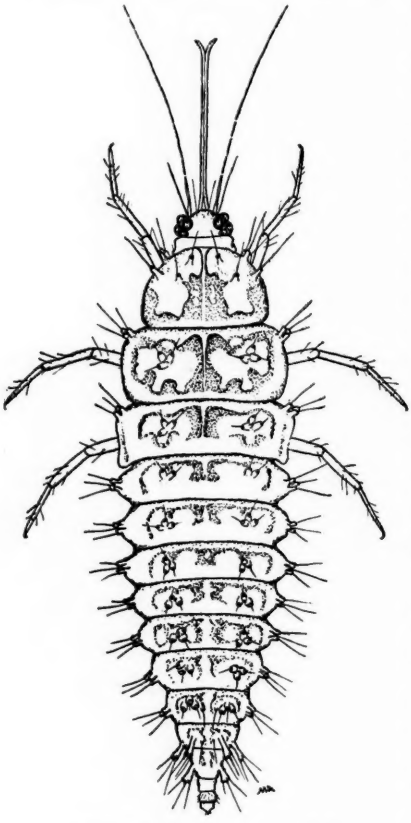

FIG. 4.— *Sisyra umbrata*, larva. × 15.

Near the point of attachment the first pair have a curious hook-like projection (*b*, Fig. 5), directed inward toward the body. This appears on the second pair merely as a knob, and gradually decreases in prominence, until it disappears almost entirely on the sixth and seventh pair (*a*, Fig. 5). On each pair of appendages except the first, at its articulation with the second joint the first one

is forked, the outer branch of the fork being longer than the inner, and both curved inward toward the body. Between these two branches the second joint is attached (*c* and *d*, Fig. 5).

The purpose of these inward-curving forks is probably to keep the respiratory filaments from too close contact with the body, and give them greater access to the currents passing through the pores of the sponge. It would seem that the first pair, having lost the fork at the terminal part of the first joint, have developed the hook-like projection nearer the base for a similar purpose. Two tracheæ can be partially traced in the alcoholic specimens, showing through the delicate outer membrane of the respiratory filaments.

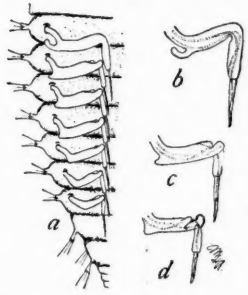

FIG. 5. — Respiratory filaments. *a*, ventral view of abdomen, × 15; *b*, left filament of first pair; *c*, left filament of third pair; *d*, right filament of fifth pair.

The mandibles and maxillæ, to fit them for piercing organs, have attained a length nearly equal to that of the antennæ (Fig. 4) and are joined to form two sucking tubes. In a cross section of these tubes (*a*, Fig. 6) the grooved edges are shown, by means of which mandible and maxilla fit each other closely. The grooved edges of both mandible and maxilla are finely serrated longitudinally, preventing them from slipping one upon another when they are used in puncturing the sponge tissue. The two readily pull apart, showing that there is no adhesion of the chitin, but that they are merely apposed. As seen in Fig. 4, these sucking tubes are conjoined for nearly their entire length, being separated only at the tip and near the base. After they enter the head they unite in a Y-shaped joint, thus forming a single tube. This Y-shaped joint can be plainly seen on the underside of the head in the chitinous shell obtained by the use of caustic potash solution. After the junction the single tube passes on

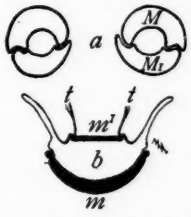

FIG. 6. — *a*, cross section of paired sucking tubes. *M*, mandible; M_1, maxilla; *b*, cross section of pharynx; *t*, tendons; *m*, m^1, points of attachment of muscles.

a nearly vertical line toward the dorsal side, where, after making a turn at right angles, it joins the œsophagus (Fig. 10).

In *b*, Fig. 6, is shown a cross section of the sucking organ (pharynx) after the point of juncture of the two tubes into one. On the anterior and posterior side it is heavily chitinized, these surfaces, together with the tendons on the anterior side, being the points of attachment for two pairs of strong muscle bands. The remaining portion of the wall of this sucking pharynx is of thin membrane. At the contraction of the muscles surrounding it, the cavity within is increased many times the size it has when the muscles are relaxed. This mechanical contrivance forms a very effective pump for drawing the juices of the sponge tissue through the sucking tubes into the œsophagus.

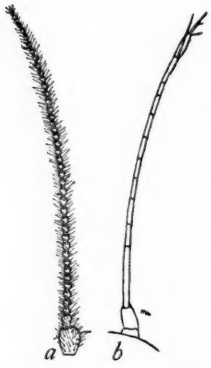

FIG. 7. — Antennæ. *a*, adult, × 18; *b*, larval, × 36.

The larval antenna has in most cases sixteen joints, those beyond the third being usually of equal length. The third is equal in thickness to the segments just mentioned, but equals in length the next three or four segments. The second is equal to the fourth in length, but is twice as thick. The first equals the second in thickness, but is only half as long. The eleventh is frequently somewhat shorter and the twelfth, somewhat longer than the fourth, but they are both equal to it in thickness. The thirteenth is curiously ovate, and the three terminal ones are very slender and bear one or two small spines. At the base of the ovate joint is a much longer spine. In Fig. 7 the antennæ of larva and adult are shown comparatively, but under different magnification.

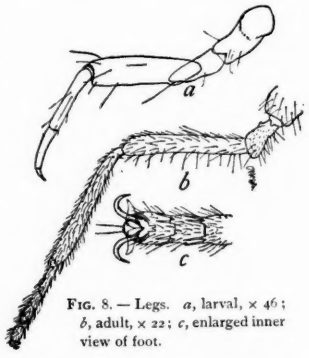

FIG. 8. — Legs. *a*, larval, × 46; *b*, adult, × 22; *c*, enlarged inner view of foot.

Fig. 8 gives a comparative view of the larval and adult leg, and a view of the lower side of the foot of the adult, showing the arrangement of claws and pulvilli, and the four large spines on the inner side of the first four joints of the tarsus. Similar spines occur on the lower end of the tibia. The larval leg has but one claw and a one-jointed tarsus. The legs of the larva are all similar. Those of the adult differ considerably; the fore legs are the shortest pair but have the coxa of unusual length, nearly equal to the tibia; in the middle leg the femur is the longest joint; in the hind leg the femur and tibia are of equal length. In all the adult legs the trochanter is much narrowed at its distal end where it articulates with the coxa.

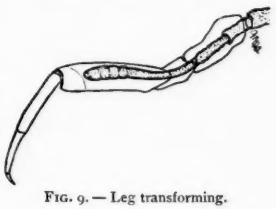

FIG. 9. — Leg transforming.

Before the pupal stage is reached, the legs pull entirely out of their chitinous covering, and the process of making over begins. In specimens lightly stained with borax carmine the adult legs can be distinctly seen developing under the old chitinous covering. This process is shown in Fig. 9, the coxa, trochanter, and femur of the adult leg being fully developed, while the tibia and tarsus with its five joints are only partially differentiated. The process of development for the antennæ and mouth parts of the adult is very similar to that of the legs, except that these adult organs, being so much larger than those of the larva, are early withdrawn entirely out of their slender chitinous sheaths, and are developed underneath the larval cuticle.

INTERNAL ANATOMY.

Fig. 10 is a diagram of a sagittal section of the larva through the median plane. The position of the brain in the prothorax has been noted in some other insects. In the very young larva the brain occupies the normal position in the head, but, as the pupal stage is approached, it gradually draws backward until it occupies the position in the thorax shown in Fig. 10. The prothorax also contains, besides its own, the subœsophageal

ganglion. The seventh abdominal segment has two ganglia, smaller than those of the prothorax but larger than the remaining eight, which are distributed — one in each of the intervening segments. The dorsal subsegment, interpolated between the prothorax and head, and which was previously mentioned, is shown here. Neither pair of the muscular bands which expand and contract the pharynx (*m*, Fig. 10), nor either of the sucking tubes below their point of juncture (*p*, Fig. 10), would be present in a section through the median plane, but I have figured them here diagrammatically for the sake of clearness.

The most difficult, and, as well, the most interesting part of this study has been the tracing of the course of the alimentary

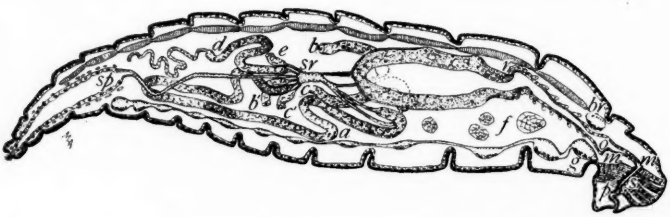

FIG. 10. — General diagram of the larva. *a*, *b*–*b'*, *c*–*c'*, three silk glands attached at both ends; *d*, *e*, two silk glands attached at one end; *sr*, silk receptacle; *sp*, spinneret; *f*, fat bodies; *br*, brain; *g*, subœsophageal ganglion; *r*, band of regenerative cells of stomach; *p*, point of junction of sucking tubes; *s*, sucking pharynx; *m*, muscle attachment of pharynx; *o*, œsophagus.

canal posteriorly from the stomach. That others have experienced like difficulties in dealing with near relatives is shown by the contradictory statements made concerning Osmylus by students of its life history (Suckow, Ramdohr, Loew, Dufour, and Hagen). I have found the work particularly difficult, as the alcoholic specimens were too brittle for dissection, and I was obliged to depend entirely upon the study of sections.

Hagen figures for Osmylus four Malpighian tubules attached at both ends to the intestine, the anterior attachment near the base of the stomach, the posterior one near the hinder end of the intestine. Three other tubules have only the anterior attachment and have their posterior end free. All of the tubules are modified in their middle portion for the secretion of silk.

Meinert found similar conditions in Myrmeleon, except that there were six tubes with the double attachment and two with free ends. He also found that there was no posterior exit from the stomach, but that the small intestine (?) had atrophied into a compact string of cells with no opening between the point of attachment of the silk-secreting tubes. The unassimilated portion of residuum is expelled as a mass after the insect has become an imago.

In Sisyra, as I have before mentioned, there is no such residuum, since the juices of the sponge are ready for complete absorption. An extensive digestive tract being in this way rendered superfluous, nature has economized by modifying a large part of the alimentary apparatus into a silk-secreting organ.

The posterior fourth of the stomach appears merely as a solid cord of atrophied cells, which ends in the walls of a dilatation, — "silk receptacle," it may be termed. The walls of this receptacle have the structure of those of the Malpighian tubules. It appears to be the outlet of five tubules, three of which are attached here at both ends, and two of which extend posteriorly and end in the body cavity. All are modified in their middle portions for the secretion of silk. The cells of the silk-secreting portion are much larger and more irregular in shape than the ordinary Malpighian tubule cells, and show the singular branched nuclei characteristic of silk gland cells in the caterpillar and other insects.

The three tubes having the double attachment proceed anteriorly to about the middle of the metathorax and are then modified at or near the point of their backward turn. Posteriorly they are modified almost immediately after leaving the silk receptacle at the base of the stomach. The two tubes having the single attachment have a considerable portion of unmodified tubule at their distal extremity, intricately coiled upon itself, as is shown by the number of variously cut sections which appear at this place in any of the three standard planes through the body. The length of the silk-secreting portion is increased by complicated coils and turns of the tubes, so that they completely fill the body cavity in the first seven abdominal segments, making it next to impossible to accurately trace

their course in sections. It seems probable, however, that there is no constancy in the nature of these coils, as the number of sections of the tubes varies greatly in different specimens. I am reasonably certain, however, of the three attached and two free tubes, as the cross sections show quite uniformly in the anterior portion of the abdomen multiples of three, and in the posterior, multiples of five. The variations from this number can be accounted for by turns in the tubes.

Connecting the silk receptable with the spinneret, which occupies the last three abdominal segments, is a tube which seems to have a straight course except for a bend ventrally in the sixth segment. This is the outlet for the silk secretion which collects first in the silk receptacle. The walls of this outlet tube have somewhat the structure of those of the Malpighian tubules, yet the cells are more regular in shape and have greater uniformity in the size and number of their nuclei. They also show, in a slight degree, the columnar nature of intestinal cells. This fact, together with the ventral bend in the course of the tube and its terminations, indicates that it is the small intestine, entirely diverted from its original function and modified so as to serve merely as an outlet for the silk secretion.

After passing through this tube, the silk collects in the spinneret, the walls of which are surrounded by bands of strong circular muscles, which aid in ejecting the secretion when the cocoon is spun.

In Fig. 10 the nature and position of the spinning glands are shown diagrammatically. The complete course of one of the three which are attached at both ends, and of one of the two which are attached at one end, is figured.

Fig. 11 shows longitudinal and cross sections of the silk glands with their fantastically formed nuclei. The typical structure of the Malpighian tubule is also shown and its gradual modification into silk-secreting cells. In *a*, Fig. 11, a section of a functional silk gland is shown, the walls being much thinner and the nuclei of simpler forms than in *b* of the same figure, where no secretion is visible. Some of the sections figured show traces of vacuolization, a common sign of the

degeneration which is characteristic of the first stage of metamorphosis. Sections of older larvæ show the silk glands in a much more advanced stage of degeneration, and numerous leucocytes in their vicinity or clinging to their walls. In the pupæ there are only a few fragments of the larval silk glands, but adult Malpighian tubules are seen forming, for which the material from the degenerated silk glands is probably again used.

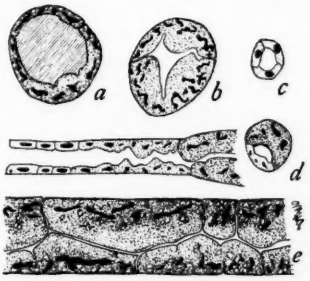

FIG. 11. — Silk gland sections. *a*, cross section of functional gland; *b*, cross section of gland without secretion; *c*, cross section of unmodified tubule; *d*, section showing gradual modification into silk-secreting cells; *e*, longitudinal section of silk gland, showing vacuolization.

Digestive Epithelium.— Sections through the digestive epithelium of a normal, feeding larva show vacuolization, even at this early stage At the anterior end of the stomach is a circular band of small cells which remain active and functional during the period of degeneration of the other epithelium. In the process of degeneration all traces of cell boundaries disappear, in some places the cell substance being a liquid mass in which float the nuclei. The disintegrated epithelium is finally cast off from the walls into the center of the cavity and the new rapidly grows out from the regenerative band to take its place, new nests of regenerative cells appearing at frequent intervals. It would seem that the solid cord of cells at the posterior end of the stomach serves as another regenerative center, since at this stage there is an opening from this end of the stomach through what was the solid cord in the larva. The adult intestine seems to be developing from the cells at this point as a regenerative center. The adult Malpighian tubules are probably also developed in part from these cells. I have seen clear evidences of a new set of these organs forming in the normal position at the base of the stomach.

FIG. 12. — Larval wing. *h*, hypodermis; *p*, peripodal membrane; *t*, trachea; *w*, wing.

DEVELOPMENT OF THE WING.

Some time before the larva spins its cocoon the wing buds begin to appear, showing through the thin skin. These form a very convenient index of the age of the larvæ. Fig. 12 represents a longitudinal section through a wing bud at an

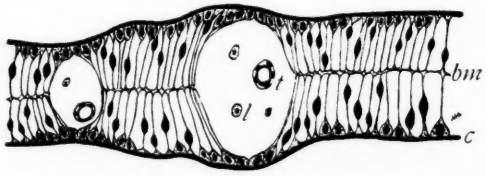

FIG. 13. — Section of older wing. *bm*, basement membrane; *c*, cuticle; *t*, trachea; *l*, leucocytes.

early stage, before it is clearly visible from the outside. The two layers of closely packed cells have not yet united. The first formation of the tracheæ is also shown.

The next stage figured is much later, when the two layers have united, leaving large openings through which pass the tracheæ, now fully developed (Fig. 13). Leucocytes are found frequently in these openings. The great stretching of the wing tissue by its growth both longitudinally and laterally has drawn the upper part of the cells into slender processes, all of

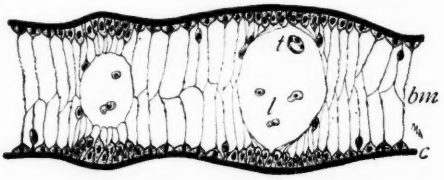

FIG. 14. — Section of older larval wing. *bm*, basement membrane; *c*, cuticle; *t*, trachea; *l*, leucocytes.

which join the basement membrane, separating the two cell layers. Many of the nuclei have been drawn up by the strain from their normal position along the layer of chitin, so that in some cases they nearly touch the basement membrane. The subsequent growth of the wing is nearly all in a longitudinal direction.

Fig. 14 shows the effect of a greater stretching in a longitudinal direction. Most of the nuclei have returned to their position next the cuticle. A very few have progressed too far for return, and are left clinging to the tracheal openings or standing alone and apart from their fellows. The cell processes are much more ragged and broken than in the last stage, and the basement membrane is pulled out of its straight line, being very uneven and irregular. Traces of the old connection may be seen, however, in the slight thickenings in the cell processes. Along the tracheal openings where the adult veins are to be, we see preparation going on for the task of depositing extra layers of chitin. At these points the cells become aggregated in two or more apparent layers and have larger nuclei.

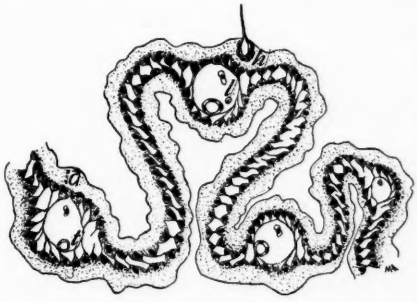

Fig. 15. — Pupal wing. *c*, rudimentary chitin; *h*, mother cell of hair; *l*, leucocytes; *t*, trachea.

The next section figured is from the wing of a pupa (Fig. 15). Here the wing has increased greatly in length and decreased in thickness. The slender cell processes have almost entirely disappeared, all the cells are on one level and have secreted a thick layer of material, which, after the final molt, will harden into chitin. Owing to the close quarters within the pupal skin, the wing has become extensively fluted and crinkled to permit the now rapid growth longitudinally. In Fig. 15 a hair cell is shown developing in the cuticle, — a large vacuolated mother cell, with nucleus at one side and small cells clustered about it.

Fig. 16. — Sections of adult wing. *a*, soon after molting; *b*, older. *t*, trachea; *h*, mother cell of hair; *l*, leucocytes.

The next stage shown is from a recently transformed adult (*a*, Fig. 16). The crinkling has disappeared, leaving the wing nearly flat. The processes are contracted within the cell body, drawing the chitinous layers close together. Near the tracheæ are shown the fully developed hair bulbs. The tracheal openings and spaces between the cells show numerous leucocytes, and all the hypodermis is engaged in the work of thickening the chitinous covering.

In *b*, Fig. 16, a section of an older wing is represented. The upper chitinous layer has become much thickened and the only traces of cells are the occasional nuclei and the thin line

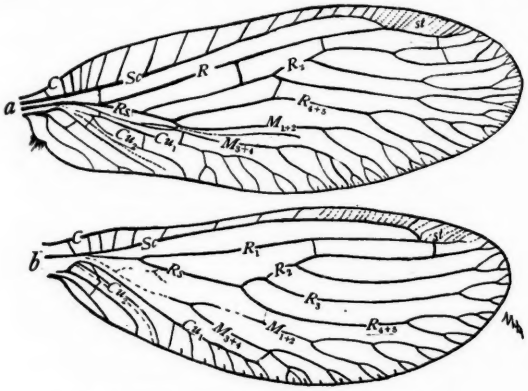

FIG. 17. — Wings of adult, × 15. *a*, fore wing; *b*, hind wing.

of protoplasm between the chitinous layers. In the wings of some insects nothing but the chitinous plates persist, but Sisyra seems to retain throughout this slight vestige of cellular tissue.

Fig. 17 shows the venation of the fore and hind wing of Sisyra. It is rather simple for this family. There are few cross veins. The course of the principal veins may be easily followed. There is, however, quite an extensive variation in the tips of the main branches. A study of this variation should throw some light on the method of evolution of the peculiar hemerobian type. I have tabulated the extent and nature of the variation in fifty wings. Fig. 18 shows the type of branching of the principal

veins, as far out as the point where they cease to be uniform, and the ten different forms of tips appended to these branches, found in the specimens studied. The branches of R_2, R_3, etc., are lettered (*a*, *b*, *c*, etc., Fig. 18), and the different types of tips numbered (1–10, Fig. 18) to correspond with the letters and numbers of the table. The variants and their frequencies are shown for each lettered tip in the table; *e.g.*, tip No. 7 — the most common type — occurs, in the fore wing, four times on branch *a*, sixteen times on branch *b*, etc.

	FORE WING.			HIND WING.		
	Left.	Symmetrical.	Right.	Left.	Symmetrical.	Right.
	1 2 3 4 5	6 7 8 9	10	1 2 3 4 5	6 7 8 9	10
a	3	4 14 1	3	2	2 18	3
b	3	2 16	4		5 20	
c		14 11			21 4	
d		5 19	1		23 2	
e	6	2 17			1 24	
f	1	22	2		4 21	
g	1	24		1	11 13	
h		7 18			14 11	
i		12 12 1			22 3	
j		11 13	1		19 6	
k	2 12	9	2	17	1 5	2
l	9	7 5	4	7	13 1	4
m	9	7 5	4	5	20	
n	11	7	7	2	22	1
o	4 16	1 4		2 7 14 2		
p		4 21			25	

From a glance at the table and Fig. 18 one sees the tendency is toward extensive multiplication of symmetrical branches on R_2, and that back of R_5 the branching becomes increasingly asymmetrical toward the left, this asymmetry culminating in Cu_1, especially in the hind wing. No variation in the cross veins of the hind wing was observed in the twenty-five specimens examined, and only a slight variation in those of the fore wing. In every case the variations noticed were in the disk of the wing, except that in two cases there was a cross vein between the first pair of secondary branches of R_2

(*a*, *b*, Fig. 18). Such a case is shown in Fig. 17. The cross vein in the basal part of the subcostal space, said by some to be absent in Sisyra, was present in every specimen. The other variations seen were in the number of cross veins between R_1 and R_2, which is normally three. In two cases four were present and in one other instance there were five. But these were all of a nature easily explainable, as there were two or three faint veins standing close together, showing that the material usually forming one vein had formed several. Between R_2 and R_3, the only other space showing any variation, the

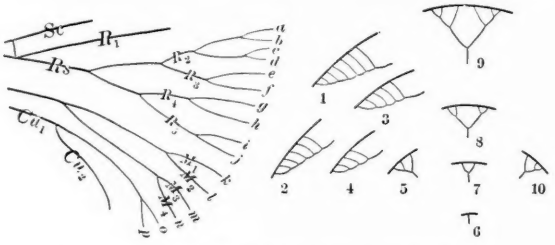

FIG. 18. — Diagram of variation in wing veins, illustrating the table.

normal number is one. In seven cases there were two, in one three, and in one four. The same tendency to have several weak veins close together was shown here. All the added cross veins were on the proximal side of the normal one. The variation in cross veins seems to have no connection with that in the tips. The specimen having the most erratic form of tip (9, Fig. 18), which occurred only once, had the cross veins entirely normal.

SUMMARY.

The points of chief interest developing from this study may be summarized as follows :

1. In Sisyra the mouth parts are not in the usual opposed position, but are approximated in pairs to form two sucking tubes, excessively elongated, and decurved.

2. The brain is in the prothorax in old larvæ.

3. The stomach has no posterior opening in the larva.

4. Three Malpighian tubules are attached at both ends, and two are attached at one end, — all metamorphosed into silk glands in their middle portion.

5. The small intestine is modified into an outlet for the silk secretion.

6. The spinneret is formed from the terminal part of the alimentary canal.

7. A completer account than has hitherto appeared is here given of the late stages of wing development, and the variations in venation of fifty wings are tabulated.

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THE REGENERATION OF THE PHARYNX IN PLANARIA MACULATA.

HENRIETTA F. THACHER.

In a paper on *Planaria maculata*, published in 1898, Morgan called attention to an important feature of the regeneration of the pharynx, namely, that in regenerating pieces which were cut anterior to the old pharynx, the new pharynx forms "at the edge of the old tissue, but lying for the most part within the *new* material," while if the cut were made posterior to the pharynx the new organ forms in the anterior end of the *old* tissue. During the next two years there appeared a number of papers describing experiments on the power of regeneration in planarians, but giving no further knowledge of the development of the pharynx except that to be derived from general statements of the various positions it may assume in the regenerating pieces. More recently a paper by Bardeen on the physiology of *Planaria maculata* has taken up the formation of the pharynx in this species and given a somewhat detailed account of it.

In studying the origin and growth of the new pharynx, I wished to find out if there were any marked difference between its formation in the *new* tissue of the anterior piece and in the old tissue of the posterior piece, since the conditions for regeneration seemed so unlike in the two cases. At the same time I was interested in observing in the posterior pieces what might be the influence of the reproductive organs when present in the region where we should expect the pharynx to appear, and if, under these conditions, the already existing cavities and external opening can be made use of. In this connection I examined series of regenerating posterior pieces in which the cut had been made (1) just posterior to the pharynx, but at a time of year when the reproductive organs have disappeared; (2) anterior to these organs when they are fully developed; and (3) posterior to them.

The greater part of the material for my experiments was collected from ponds near Woods Hole during the months of June, July, and August, and was preserved for study in the following winter. Later in the year more planarians were found near Bryn Mawr, and were kept in aquaria until needed. Each worm was cut into three pieces, of which the middle, containing the pharynx, was rejected, and the anterior and posterior pieces were allowed to regenerate. The latter were killed at intervals of twelve hours for about eight days, at the end of which time those remaining had begun to feed. Where it seemed advisable, series were killed at closer intervals, but as a rule this was not necessary. The pieces remained in corrosive acetic for about ten minutes; after cutting they were stained on the slide in Delafield's hæmatoxylin, and then dipped for a few seconds into a strong solution of aniline orange. The latter differentiates the endoderm, muscle bands, yolk cells, and the lining of the reproductive system.

Soon after the worms are cut, the edges of the cut-end draw together and matter from the digestive tract and loose parenchyma tissue collect about the injured region. Within a few hours the surface opens out again, until only a slight depression marked by a dark line of pigment is noticeable. In the mean time parenchyma cells collect at the cut surface and form a narrow sheet across it, while cells from the margin of the uninjured epithelium push out and cover the new growth. This overgrowth of epithelium is comparatively rapid, as the cells in this region flatten out and cover individually a much larger area. By the end of the first day the tip has become rounded and the anterior end is covered with an epithelial layer; later, with the increase in their number, the flattened cells resume their columnar form.

The parenchyma of the normal planarian appears on examination as an ill-defined mass filling in the spaces between the organs. Its protoplasm stains very slightly, but the tissue is conspicuous owing to the many deeply colored nuclei that are present in it. These nuclei are occasionally seen in small groups, but they are usually scattered and separated from each other by the loose spongy tissue. Among the parenchyma

cells are found other cells which are specialized in function,—large rhabdite cells, lying just below the ectoderm and showing the rhabdites buried in the protoplasm, and the mucous cells, staining an intense blue; also, along the digestive tract, a few large granular cells for which Bardeen has suggested a digestive function. In addition, I have noticed some large cells staining with aniline orange, which seem to contain some such material as yolk. Whether this is a fourth kind or merely the digestive cells I have not been able to decide. There are also present elongated connective-tissue cells.

Although the majority of the parenchyma cells show little protoplasm, scattered through the tissue of the normal uninjured animal there are a good many cells whose nuclei resemble those of the ordinary parenchyma, but which have gathered about them an irregular mass of granular protoplasm. As many of these are in various stages of division, while I have found no division among the cells with less protoplasm, it is probable that the accretion of protoplasm is the usual forerunner of division in the parenchyma cells, and that the number of the latter is constantly increasing even in normal planarians. While the number of these dividing cells differs individually, they are often very numerous and are confined to no one region of the body, except that they are more rare in the extreme tips. The dividing cells stand out very distinctly as they are larger and seldom have other cells near them.

After the animals are cut, the amount of division increases somewhat throughout the whole body, but very markedly near the injured surface. Cells also migrate down into this region and form there a thickening which rapidly enlarges. That migration takes place is indicated by the long trails of protoplasm that give to the cells a bipolar appearance with the axes directed towards the growing mass (Fig. 1), while in the normal planarian there is no such effect and the cells are more irregular and rounded in outline. After the thickening has reached a certain degree of concentration there is rarely any cell division in the proliferated mass, but mitotic figures can frequently be found in the region near by, where the cell mass is less dense. Cells also continue to migrate into the new part and

add to the new growth. The number of cells in the parenchymatous tissue of the body itself is also usually much increased as the nuclei throughout continue dividing, and by the time the pharynx thickening appears, which is in the course of the third day, the tissue is filled with cells conspicuous on account of their greater amount of protoplasm.

I shall consider first the growth of the pharynx in the anterior piece and then that in the posterior piece. By the time the proliferation of cells in the regenerating posterior tip is quite marked, a slight shift in the direction taken by some of the cells denotes the beginning of the new pharynx. The cells now collect just on the line between the old and new tissue at the posterior end of the digestive tract, which has rounded off, and usually has begun to bud out side branches. As is true of the growing end, so here, when the thickening becomes marked, no division of cells can be found in it, but in the less dense tissue around it there are many dividing cells and apparently considerable cell migration towards the new growth. The collection of cells stains very deeply in comparison with the old tissue near by, due probably to the greater amount of protoplasm in this region.

The thickening for the pharynx grows until it is quite large, and then the split for the pharynx chamber begins. This opens up very rapidly as a narrow cavity running across the base of the thickening and up on the sides, being usually more advanced on the ventral than on the dorsal side. It is at first irregular in outline, but the cells along the edge soon flatten out into a thin lining epithelium. As development proceeds, cells are added at the anterior end of the new pharynx, while there is no division in the compact mass of cells already collected (Fig. 2). About the fourth day the lumen of the pharynx itself appears in the center of the proliferation, due to an elongation and pulling apart of cells which become larger and thin walled and form the lining of the pharynx. This cavity gradually enlarges posteriorly to open into the pharynx chamber, and anteriorly to unite with the wall of the digestive tract, which then breaks through to join with it. The new region has in the mean time steadily increased in

length, and the branches of the intestine have pushed back into it, while the central digestive cavity has also somewhat enlarged. Shortly after the lining of the lumen has formed, the muscle bands of the pharynx differentiate. They arise from cells just between the two epithelial layers; they elongate and undergo some change in their constitution, since they stain with aniline orange very shortly after the lengthening process has begun. The change is first visible in the region where the pharynx is continuous with the body of the animal

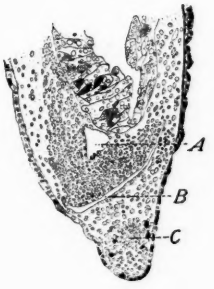

FIG. 2.

FIG. 1.

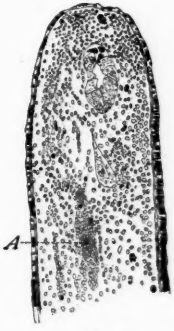

FIG. 3.

FIG. 1. — Large parenchyma cells migrating towards regenerating region.

FIG. 2. — Pharynx in anterior piece at close of fourth day. The lumen has just appeared. *A*, lumen; *B*, lateral digestive branch; *C*, pharynx chamber.

FIG. 3. — Pharynx in posterior piece at close of third day. The lateral digestive branches have met, and the pharynx thickening (*A*) is conspicuous. There are many dividing cells present.

and extends gradually posteriorly. So far as I could determine, the circular muscles develop before the longitudinal, but if so, the difference in time is very slight. In the course of the fifth or sixth day the pharyngeal chamber opens to the exterior by an ectodermal invagination from the ventral surface, and shortly afterwards the animal begins to feed.

The shape and size of the pharynx vary comparatively little after the inner lumen appears. At first, before the formation of this cavity, the shape is slightly pointed, but it soon becomes more regular and assumes the form of the normal pharynx, except for its length, which is only about once and a half or twice the breadth. The addition of cells at the anterior end

does not continue after the structure is well organized, and the latter part of the time needed for the regeneration of this organ is occupied in changing the parenchyma cells into the different tissues. Up to the time when the muscles appear, the cells still remain crowded together and show by their deep color the presence of unusually dense protoplasm. After the muscles are well formed the tissue assumes a less dense appearance, and this change arises apparently at the same time in the cells throughout the new tissue. Deeply staining masses, as of mucous, can also be seen, so that the tissue soon resembles that of the normal worm.

The process of formation of a new pharynx in the old tissue of the posterior piece seems to be very similar, and equally simple during the nine months of the year when the reproductive organs are absent. The overgrowth of the cut surface and the increase in the number of dividing cells is just as was found in the anterior piece. The pharynx thickening, however, appears about twelve hours later than in the former case, *i.e.*, about the end of the third day, and is usually noticeable shortly after the two branches of the digestive tract have joined. But that the pharynx is formed with relation to the "axial gut," as Bardeen states, I am not prepared to say, as occasionally a case is found in which the branches have not met, although a thickening is present, and often in a slide showing a conspicuous gathering of cells the union between the intestines has barely taken place. The pharynx forms a short distance posterior to the cut, in the old tissue. It is first made visible by the shifting of the axes of some of the cells, which now direct themselves toward the new point of activity, and the thickening increases rapidly (Fig. 3). The cavities open up just as in the anterior piece, but the chamber is apt to be much longer and more irregular in outline than in the other case. Later the enlarged cavity rounds off so that the chamber resumes its normal size. The central cavity of the digestive tract enlarges in a posterior direction, and at the same time the pharynx thickening is added to by cells at the anterior end; thus, by the time the pharynx is ready to open up, the original space between it and the

digestive tract is bridged over (Figs. 4, 5). The appearance and development of the lumen, muscle bands, and normal spongy tissue is identical with that in the anterior pieces, and the posterior piece is also ready to feed in seven days.

Summing up these results, it appears that the regeneration of the pharynx in the new and in the old tissue is much the same, (1) as to the origin and migration of the cells, (2) as to the formation of the two cavities (the chamber and the lumen of the pharynx), and (3) as to the differentiation of the cells into the normal tissues. They differ (1) in the length of time that elapses before the pharynx thickening shows itself (about twelve hours more being required for its appearance in the old tissue than in the new), (2) in the position of the developing

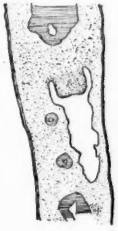

FIG. 4.

FIG. 5.

FIGS. 4, 5. — Stages in development of pharynx in posterior piece.

pharynx with regard to the central digestive cavity, and (3) in the size of the pharyngeal chamber as shown by its early irregularities in the posterior piece. The last two differences are probably due to the disposition of the digestive branches in the two cases.

In the early part of the summer the reproductive organs of this species are fully developed, and regeneration under these conditions is especially interesting. The genital apparatus lies for the most part in the region just between the pharyngeal and genital pores, so that when an animal is cut just posterior to the pharynx these organs occupy the region where the new pharynx should develop. Under these conditions there is no sign of the growth for the new pharynx until towards the end of the fourth day, when a small collection of cells can

be found in a ventral but not necessarily median position. Also this mass is usually at a normal distance from the fused intestine. Morgan (1900) has noted this delay in the formation of the pharynx when the worm is cut anterior to the genital pore at this time of year (July 2) and finds about twelve days instead of seven required for complete regeneration. His later experiments, begun July 31, gave different results, but this was probably due to the degeneration of the reproductive organs between these two dates, as he found that the time required for this set of pieces to become complete animals was only seven days.

This delay may be due to the scarcity of parenchyma cells in this region, which is almost completely filled by the tissue of the genital organs. When these organs are fully present the parenchyma cells collect as shown in Fig. 6, migrating principally from the anterior end into the region of parenchymatous tissue that lies just ventral to the penis. In this drawing are shown in the tissue along the edge of the genital organs certain irregular breaks that seem to appear at the beginning of the degeneration of these structures. The pharynx forms ventral to such cavities, and the split for the pharynx chamber is at first entirely independent of them (Figs. 6, 7). Later the wall between may break down, and thus greatly enlarge the chamber, but if so it is a secondary process; there is also a tendency towards degeneration in the thin line of tissue between the pharynx and reproductive chambers, as shown by the dotted line in Fig. 7. In no case, however, does the old genital pore become the new pharyngeal pore.

As the genital organs degenerate, which I have found takes place during the last two weeks in July and the beginning of August, the region in which the pharynx appears becomes quite irregular. The only feature that seems at all constant is the relative distance between the cross-branch of the intestine and the pharynx thickening. That this is true may be seen by a study of its position with relation to that of the genital pore. The main genital duct opening to the exterior persists longer than any other part of these structures, but its presence

seems to have little or no influence on the position of the new pharynx. The latter may appear far anterior to it, posterior, or, as in Fig. 8, it may assume an eccentric position and lie on the same level; in this case the duct and pore are shown by dotted lines, as the pharynx lies about eight sections to the side of the median line, *i.e.*, of the genital pore. Thus the new pharynx can be found in all possible positions, and the varia-

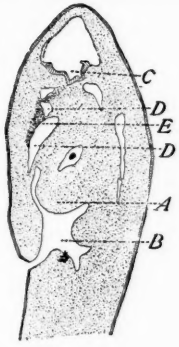

FIG. 6.

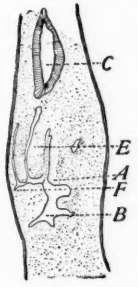

FIG. 7.

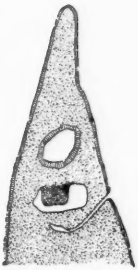

FIG. 8.

FIGS. 6, 7. — Development of pharynx during presence of reproductive organs. *A*, penis; *B*, genital chamber; *C*, digestive tract (in 6 the wall has broken down between it and the degenerating cavity); *D*, cavities due to degeneration of reproductive organs; *E*, pharynx; *F*, position of pharyngeal pore.

FIG. 8. — Position of regenerating pharynx with respect to genital duct and pore. The new organ appears to one side of the pore but on the same level. The dotted lines indicate direction of duct in following sections.

tions, such as lateral, ventral, and oblique, should be noted in connection with any hypothesis of the relation of the pharynx to the axial gut.

As regards the process of regeneration in the posterior pieces of worms cut behind the genital pore when the reproductive organs were believed to be fully developed, the process of formation seems identical with that which takes place during the absence of these organs. Consequently there is no need to describe what takes place.

I wish to express my indebtedness to Prof. T. H. Morgan, under whose direction this work has been done.

BIOLOGICAL LABORATORY, BRYN MAWR COLLEGE.

A STRUCTURAL FEATURE CONNECTED WITH THE MATING OF DIEMYCTYLUS VIRIDESCENS.

WILLIAM A. HILTON.

THERE seems to be very little doubt at present that the fertilization of Urodela is internal. Since Spallanzi in 1785 proved internal fertilization must take place with Triton, many investigators have shown conclusively that such is the case in other species.

The mating habits of a number of salamanders have been observed, but very much is yet to be learned about many forms concerning which we now know little more than the mere fact that fertilization is internal; however, it seems very probable that in all Urodela fertilization is accomplished by a similar method. In most cases the courtship is more or less complicated and terminates with the female following the male, who emits a spermatophore containing zoösperms, which is received by the cloaca of the female as she passes over it.

There are many variations in the mating habits of different forms described, but unfortunately few species are easy to observe. Of American forms practically nothing is known of the more terrestrial species. *Diemyctylus viridescens* and *D. torosus* of the aquatic species are about the only ones in which a satisfactory idea of the mating has been obtained.

A number of observations have been made upon European salamanders by Robin ('74), Gasco ('80), and Zeller ('90), who have given good accounts of their habits. With Triton, for instance, Zeller has carefully described the antics of the male before the female; these may extend over a period of hours; he rubs against her and rushes before her. At length she is attracted by him, and as he moves off she follows and receives

in her cloaca the spermatophore which he emits. This method of mating is very commonly described among salamanders, but variations occur; for instance, in *Salamandra maculosa*, and in *Salamandra atra*, Siebold ('58), Pfitzner ('80), and others describe the male perched upon the female's back; he clasps her for a period before spermatophores are voided. In these cases the male is usually perched upon the center of the female's back. In *Megapterma montana* and several others Bedriaga ('82) says the male grasps the female and emits spermatophores while still clasping her.

Ritter ('99) in *D. torosus* described, so far as he was able, a method of fertilization similar to that given by Bedriaga in several species; that is, the male emits spermatozoa while clasping the female. The mating of *D. viridescens* has been carefully described by Zeller ('90), Gage ('91), and Jordan ('91), and, so far as the final result is concerned, the process may be said to be similar to that described by Zeller and others for many forms of Salamandridæ, but in several particulars the mating habits are peculiar and deserve further attention.

As breeding season approaches with Diemyctylus, a crest appears upon the already broad tail of the male, and the cloacal regions of both male and female enlarge. It is stated by some that during this time the colors of the male become brighter; but this is probably exaggerated, as there is but little difference in the color of the male and female at this time, except possibly one or the other may have recently passed the red land stage and not yet attained the deeper color of the more mature individuals, or it may have just shed its skin. With Diemyctylus there is much less difference in the sexes than is found in many European Urodela, yet there are several striking differences, most of which have been noted. The female differs from the male at all seasons of the year by having more slender hind legs, and during breeding season there are on the undersides of the male's hind legs black, wartlike, horny elevations, probably developed to aid the male in clasping the female. These have often been described, but as this method of clasping the female is rare with European species, the occurrence of these organs is seldom mentioned with them.

Cope ('89) in his work on Batrachia describes a series of three to four pits along the sides of the head just back of the eye; he regards these as not constant for the species (Fig. 1).

After examining a considerable number of animals I have come to the conclusion that these pits are constant structures. In adult males there are usually three to four quite large, deep pits, which can be seen without difficulty extending from just back of the eye along the side of the head. In adult females, as a general thing, one would say there are no pits, but on a more careful examination one to four small depressions are often seen; these usually appear as pin pricks, or minute depressions in the skin. They are similar in structure to those found in the adult males, but are much smaller and less developed in the female.

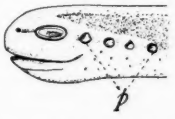

FIG. 1. — Side view of the head of an adult male Diemyctylus. *p*, pits. About natural size.

In early larval forms there are no signs of depressions or pits in either males or females, but in medium-sized to large red males there are along the sides of the head minute depressions which look very much like those found in the adult females, and more or less advanced, according to the size of the animal.

In early red females, as a usual thing, no pits are found, but in later red forms small beginning pits are sometimes present and sometimes absent; but judging from all the individuals examined it may be stated that as a usual thing these small pits of the female make their appearance at about the time the red land form changes to the viridescent water form, and that the corresponding structures in the male make their appearance in the small red forms about the time that their sex can be determined by dissection.

Before speaking of the significance of these structures which are so well developed in the adult male and so rudimentary in the female and young, it will be necessary to speak somewhat further of the mating habits. Usually in captivity during the fall, winter, and spring the male at once settles upon the female's back and clasps her just in front of her fore legs with his powerful back legs in such a manner that it is impossible for her to escape and, at the same time, possible for him to

bring his head down in contact with hers. Although she is unable to escape, in many cases she may struggle, carrying the male with her for a short distance ; but usually it is the other way, and the male jerks the female about after having been perched quietly on her back for a short time. This jerking about is not without system, for almost invariably the male jerks the female somewhat and places one side of his head just below the top and a little back of the eye, in contact with that of the female, leaving his head there for a few seconds and waving his tail with a gentle fanning motion. After a short period he jerks the female about in such a way that the other side of his head occupies a similar position in regard to the female's nose, pulling her violently in order to do this. This touching one side of his head and then the other side to the female's snout, accompanied by the more or less necessary jerking about in the water and fanning movements of the tail, continue for some time, and after a considerable number of these jerkings the male slowly leaves the female, his cloaca expanded, and is usually followed closely by the female, whose nose is near his tail. The male moves slowly forward and throws his body into serpentine undulations, and a spermatophore is emitted which may come to the cloaca of the female as she follows him farther along.

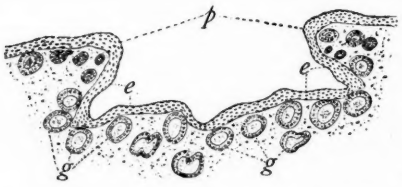

FIG. 2. — Section of a pit and glands of an adult male Diemyctylus. *g*, gland tubules; *e*, epithelium of pit. × 30.

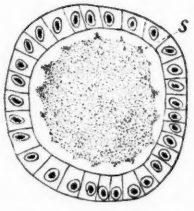

FIG. 3. — Section of a tubule of an adult male Diemyctylus. *s*, secretion. × 210.

The question naturally arises as to what relation these constant habits have towards the accomplishment of fertilization; of course it is evident that it is necessary for the male to be followed by the female in order that she may receive the spermatozoa which he emits in masses or spermatophores, and her following him may be due to an attraction which he exerts over her, but what is the nature of this attraction ?

As indicated by Jordan ('**91**), and as simple experiments in feeding captive Diemyctyli show, probably the strongest sense of the newt is either the sense of smell or the tactile sense ; the sense of sight is not particularly well developed. Now, to return to the pits on either side of the head ; upon sectioning these pits it was found that a number of simple gland tubes were collected about the bases of the pits, and these tubules (Figs. 2, 3, 4), although not opening widely in the pits when not active, may be seen to have places where the cell nuclei were drawn out and arranged parallel with the epithelial nuclei ; but when the glands are filled with secretion a few well-marked openings into the pits may be found (Fig. 5). These pits are formed from simple depressions or ingrowths of epithelium, and the epithelium which lines the pits does not differ in any way from that which covers the surface of the body (Fig. 6). The pits were found to begin in about half-grown red males or very late red females. As adult life is reached these pits or depressions become broader, and usually deeper, and together with this broadening and deepening there is an increased development of the glands, which become very numerous in adult males.

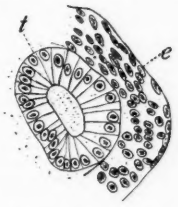

FIG. 4. — Section of a tubule and pit epithelium from an inactive gland of an adult male Diemyctylus. *t*, tubule; *e*, epithelium. × 210.

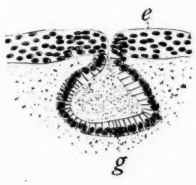

FIG. 5. — Section of a tubule from an adult male Diemyctylus, showing the opening into a pit. *e*, epithelium; *g*, gland tubule. × 105.

The glands are first formed when the pits are hardly more than narrow insinkings of the skin, and, as Ancel (**1901**) states for other skin glands of Amphibia, they are derived from the ectoderm. The cells which form the rudiments of these glands are derived from those of the insinking, or directly from the adjoining surfaces of the skin (Fig. 7). The little masses of cells which develop into glands become nearly separated from the epithelium

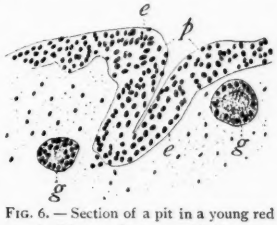

FIG. 6. — Section of a pit in a young red male Diemyctylus. *e*, epithelium; *g*, rudimentary gland tubules. × 105.

from which they were derived, and the communications with the exterior by means of minute ducts are not formed until much later. The cells of the early rudiments of glands soon begin to be arranged in a more and more columnar manner, and after they are arranged in this way the duct to the exterior is formed partly from cells of the gland itself and partly from the epithelium of the pit. The fully developed gland is simple, saccular, or slightly tubular, with a very small duct. Sometimes glands are found which seem to be partially divided into several portions; that is, have one, two, or more lumens branching off from the main one (Figs. 8, 9). New glands are formed from the old ones in this way, and although these dividing tubules are found most abundantly in half-grown specimens, a few of them are often found in the adult. These glands are more perfectly formed in those individuals where the pits are best developed; but those in a very active condition, with their lumens widely distended, were only found in adult males during the breeding season. During the mating season, either in fall or spring, these glands were very much enlarged in the adult males, their epithelial cells were much like low cubes, and the tubules possessed large lumens (Figs. 3, 10).

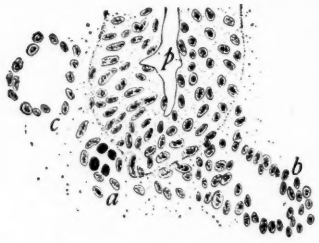

FIG. 7. — Section of a pit of a young red male Diemyctylus. *p*, pit; *a*, early stage of a developing gland; *b*, later stage of developing gland; *c*, still later stage of developing gland. × 210.

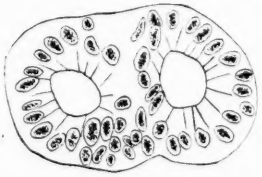

FIG. 8. — Section of a tubule from a red male Diemyctylus of nearly adult size. × 260.

When these glands were sectioned out of breeding season a very marked contrast was noticed; their lumens were much diminished, the cells reached and nearly touched in the center and no colloid secretion was present (Fig. 4). These little pits of the immature animals or of the adult females have at their bases a few masses of cells, or a few small gland tubules, which are undoubtedly the beginnings or remnants of the

glands so characteristic of the adult males (Fig. 11); sometimes one or two tubules appear to have secretion in the lumens, and some have openings into the pits.

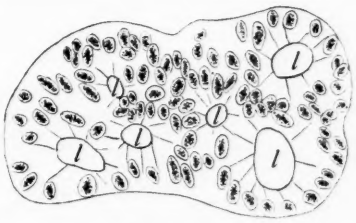

FIG. 9. — Section of a tubule from a red male Diemyctylus of nearly adult size. *l*, lumen. × 260.

To recapitulate: The pits in the adult males are almost invariably well marked, while those in the females, when they occur, are rather difficult to detect; and then, too, the gland tubules in the male are very numerous (Fig. 2). Adult males taken at other times than the breeding season, as a usual thing, show the gland tubules in a resting state; the lumens of the glands commonly have the cells almost touching each other at the center, but males taken when breeding show these gland lumens filled with secretion and the cells appear as a low epithelium.

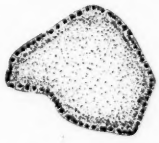

FIG. 10. — Section of a gland tubule from an adult male; taken during mating. The tubule is filled with secretion. × 105.

It may be that these glands which are developed so extensively in the male, and placed in a position which favors them, are for the purpose of attracting the female by means of some secretion.

Although, as already spoken of, similar mating habits have in general been described, they are not exactly the same as in *D. viridescens*, nor have similar glands or pits been described for other forms. Ritter, in an interesting paper on *Diemyctylus torosus*, describes no such structures, nor was I able to detect any trace of such pits or glands in several specimens examined; and, in fact, as already stated, the mating habits are entirely dissimilar in the two species.

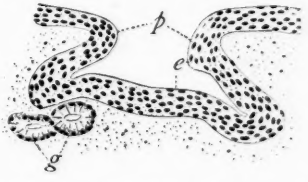

FIG. 11. — Section of a pit from an adult female Diemyctylus. *e*, epithelium of pit; *g*, rudimentary gland. × 105.

GENERAL SUMMARY.

1. The glands on the side of the head of *D. viridescens* reach their complete development only in adult males, and according to my observations are most active during the time of mating.

2. The pits are formed from invaginations of the epidermis, and the gland rudiments are derived from these invaginations or from the adjoining epidermal surfaces.

3. Adult males always possess three to four large, well-marked pits. Adult females sometimes have one to four pits on a side, and also a few small gland tubules, some of which may open into the pits.

4. Early red larval males have small pits about as soon as the sex can be determined by gross dissection, and at the bases of the pits there are usually a few small gland tubules.

5. Pits when present in red females make their appearance *late*, usually just before the red terrestrial changes to the viridescent aquatic form; at this time the pits are seen to be shallow depressions of the skin, and no gland tubules are present.

6. No pits or glands were found in the early larval form of *D. viridescens*.

7. The glands described occur only when pits are present, and the tubules have openings into the pits in the adult males, and sometimes in the females.

8. In mating, the female follows the male only after the usual courtship, in which first one side and then the other side of the male's head touches the female's snout.

In the preparation of this paper I have become greatly indebted to the Department of Histology of Cornell University and the professors in charge, and also to Mrs. Gage for lending me her slides of Diemyctylus heads to complete my series of stages.

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SOME HITHERTO UNPUBLISHED OBSERVATIONS OF ORESTES ST. JOHN ON PALEOZOIC FISHES.

C. R. EASTMAN.

Mr. Orestes St. John, the only pupil of Professor Louis Agassiz who took up the study of fossil fishes, and whose researches in this class of vertebrates, published in Vols. VI and VII of the *Illinois Palæontology*, are among the leading contributions to the literature of American Paleozoic forms, passed his early life in the vicinity of Waterloo, Iowa, and during a period of fifteen years, dating from 1863, brought together one of the finest collections of Meso-Devonian fish remains ever obtained from that state. This collection has recently been deposited in the Museum of Comparative Zoölogy at Cambridge, where Mr. St. John was formerly assistant in paleontology, and it is understood that further collections from the Carboniferous of the Mississippi valley are to follow. In the same institution are also preserved some of the type specimens which are described in Vol. VII of the *Illinois Reports*, with casts of others that are now in the State Museum at Springfield, Illinois.

Accompanying the St. John collection of Devonian fishes is a manuscript description and drawing of a nearly perfect mandibular (gnathal) plate of *Dinichthys pustulosus*, an interesting species whose occurrence in Iowa, Illinois, and Wisconsin has only recently been made known. As this species was originally described from portions of the dermal armor, examples of the dentition being at that time unknown, and as doubt has been expressed [1] whether it really pertains to Dinichthys rather than to some other coccostean, it is of interest to find its dinichthyid nature confirmed by this early discovery of St. John's, the credit

[1] Dean, D. Palæontological Notes, *Mem. N. Y. Acad. Sci.*, vol. ii (1901), p. 122.

for which is after a long period of oblivion finally secured to him. The actual specimen, whose description follows, appears to have dropped out of sight altogether; but if still in existence, the present account may perhaps lead to its resurrection.

Other interesting observations of St. John with reference to Edestus and Cochliodus are contained in the form of a personal letter to Professor Agassiz, written in 1871, extracts from which are quoted in the following, and his sketch of *Edestus minor* is here reproduced. Detached segments of *E. heinrichi* have been figured by Newberry[1] and Trautschold,[2] and a corresponding example of *E. minor* from the vicinity of Moscow is described by Karpinsky,[3] but St. John's specimens are the only ones, so far as the writer is aware, that have been found of the latter species in this country.

Professor Agassiz was one of the first to pronounce upon the nature of these problematical fossils, and compared them with the rostral prolongation of Pristis. Leidy saw in their segmented condition a resemblance to the compound maxillary of Lepidosteus, but later regarded them as elasmobranch spines, an opinion concurred in by Sir Richard Owen, Newberry, Woodward, and most modern writers. They are now definitely determined, however, to be the symphysial dentition of cestraciont sharks.[4]

I. On the Occurrence of Dinichthys in the Hamilton Limestone of Illinois.

(August, 1882.)

"Professor A. H. Worthen has obtained from the Devonian limestone of Andalusia, Rock Island County, Illinois, a nearly perfect example of the right mandibular dental plate of a small species of Dinichthys, which is quite distinct from either of the two forms already described by Dr. Newberry from the Ohio

[1] *Ann. N. Y. Acad. Sci.*, vol. iv (1888), Pl. V, Figs. 2 *a*, 2 *b*; *Monogr. U. S. Geol. Surv.*, vol. xvi (1889), Pl. XXXIX, Figs. 2 *a*, 2 *b*.

[2] *Bull. Soc. Imp. Nat. Moscou*, vol. lviii (1883), Pl. V, Figs. 1, 2.

[3] *Verh. k. russ. Mineral. Ges. St. Pétersbourg* [2], vol. xxxvi (1899), pp. 381, 450, Text-figs. 15, 62.

[4] *Geol. Mag.* [4], vol. ix, p. 148; *Bull. Mus. Comp. Zoöl.*, vol. xxxix (1902), No. 3.

Shale [*D. herzeri* and *D. terrelli*]. The age of the beds from which this specimen was derived is unquestionably not later than the Hamilton, as is shown by associated Brachiopoda, etc., characteristic of the Hamilton of Iowa and Illinois. The present specimen, therefore, affords the earliest indication of this genus yet discovered.

"The characters displayed by the Illinois specimen, which serve to distinguish it from the Ohio forms, may be summarized briefly as follows:

"1. The dental plate under discussion, while resembling *D. herzeri* in general form and proportions, differs from the latter in the character of the cutting edge, which is destitute of the series of conical denticles occurring in that species. The dentary portion of the mandible is similarly well demarcated from the spatulate posterior shaft, and is similarly rounded along the front margin. The anterior beak is much produced, irregularly lozenge-shaped in transverse section, with a sharply rounded anterior angle and a sharp posterior cutting edge. A deep notch separates the cusplike beak from a low, round-crested prominence in advance of the cutting edge of the dentary, which is deeply beveled along its outer face by attrition against the upper dental plates. To the same cause is probably to be ascribed the gently concave curve of the trenchant border itself. The latter terminates abruptly behind, and along the posterior slope of the dentary are to be counted the bases of five small downwardly directed denticles. The lower portion of the posterior slope is smooth and meets the shaft in an obtuse angle. In this denticulation of the posterior slope of the dentary, and perhaps also in the presence of an elevated prominence or denticle behind the anterior beak, are to be found the principal differences between the present specimen and *D. terrelli*.

"2. The form of the shaft is not unlike that of *D. herzeri*, except that it is more contracted immediately behind the dentary portion, and more regularly arched along its lower border before passing into the acutely rounded posterior extremity. The general outline of the shaft is spatulate, its outer face moderately convex, and it is separated from the dentary portion

by a shallow, curved depression. *D. terrelli* has a relatively shorter and more massive posterior shaft. As contrasted with the compact structure of the dentary portion, which has almost the density of enamel, the spatulate shaft is finely striato-punctate, and presents more the condition of osseous tissue.

"3. In *D. herzeri*, the secondary prominence or denticle behind the anterior beak is buttressed on the inner side by a prominent angulation or ridge [this is really part of the denticle, and occurs in other species as well], which sweeps from the apex of the denticle downward and backward until it merges with the thickened portion of the dentary bone. But in the

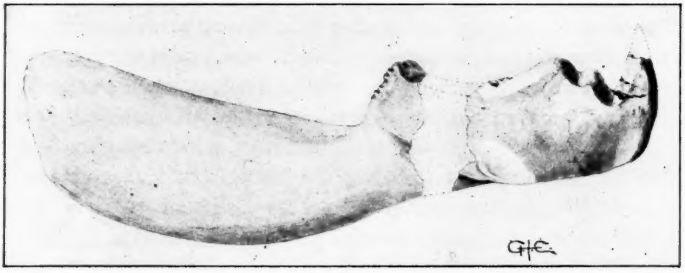

FIG. 1. — *Dinichthys pustulosus* Eastm. Hamilton limestone; Andalusia, Ill. Right gnathal plate. × ½ (nearly).

present species the entire inner surface is deeply excavated, and there is no evidence of a buttress having occurred.

"4. The present specimen evidently belonged to a species of much smaller size than either *D. herzeri* or *D. terrelli*, since the total length of the mandible is only 20 cm., while both of the Ohio forms exceed 60 cm. That it does not pertain to an immature individual seems plainly indicated by the marks of wear, and general appearance of the bone.

"The salient features which have been pointed out in the foregoing are sufficiently characteristic to warrant the establishment of a new species, which we have pleasure in naming in honor of Dr. J. S. Newberry, to whom we owe the admirable notice of the two first discovered species. In the accompanying figures are shown (*A*), view of right mandibular ramus from

external aspect; (*B*), inner aspect of anterior portion of the dentary; and (*C*), inferior view showing external outline and channel separating the dentary portion from the shaft.

"*Horizon and Locality:* — Hamilton Limestone; Andalusia, Rock Island County, Illinois."

[NOTE. — The specific title which St. John had intended to propose has already been applied by Dr. J. M. Clarke[1] to a gnathal plate from the Hamilton of western New York. Moreover, although St. John clearly has the priority of discovery, the species which he here recognizes as distinct has been described under the name of *D. pustulosus*.[2] Only one of the

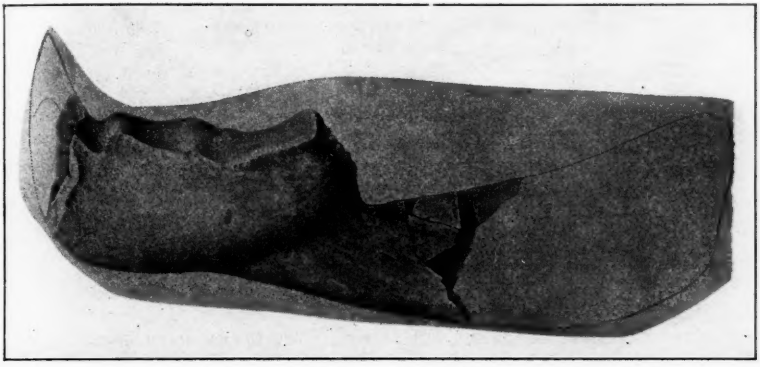

FIG. 2. — *Dinichthys pustulosus* Eastm. Hamilton limestone; Milwaukee, Wis. Left gnathal plate. × ⅔.

illustrations to which he refers is now extant. It is reproduced in the accompanying Fig. 1, and in Fig. 2 is shown a corresponding dental plate belonging to an individual of about equal size from the Hamilton of Milwaukee, the original being preserved in the Milwaukee Public Museum. A fragmentary gnathal of *D. pustulosus*, from the Hamilton of New Buffalo, Iowa, is also preserved in the Museum of Comparative Zoölogy at Cambridge.]

[1] *Bull. U. S. Geol. Surv.*, No. 16 (1885), p. 17, Pl. I, Fig. 1.

[2] *Bull. Mus. Comp. Zoöl.*, vol. xxxi (1897), p. 38, Pl. III, Fig. 4; *Amer. Nat.*, vol. xxxii (1898), p. 748, Figs. 1, 2; *Journ. Geol.*, vol. viii (1900), p. 32, Fig. 1.

II. OBSERVATIONS ON EDESTUS AND COCHLIODUS.

(From a letter addressed to Professor Louis Agassiz, dated Springfield, Illinois, June 29, 1871.)

"MY DEAR PROFESSOR:

"Excuse this postscript, but I met with rare success yesterday morning, in the finding of what appears to be the terminal denticle of an immature *Edestus vorax* [*sic*] Leidy. This is

FIG. 3. — Detached segment of *Edestus minor* N. and W. Coal measures; Illinois.

the second specimen known to me in which only a single denticle occurs — the other one, from a similar horizon in the Coal Measures, being referable to *Edestus heinrichi* N. and W., and readily distinguished from the former species by the stronger [development] and more erect position of the denticles. The slight depression at '*a*' [Fig. 3] indicates the area occupied by the overlapping of the posterior extremity of the succeeding [*i.e.*, preceding] denticle, which, however, is not developed in the present individual.

FIG. 4. — *Cochliodus sancti-ludovici* (St. J. and W.). St. Louis limestone; Alton, Ill. Enlarged.

"I also received last evening a remarkably beautiful specimen of Cochliodus sp. from the St. Louis limestone. The specimen is very small, and presents two, or a pair, of the large posterior teeth in their relative position; but what is particularly interesting, it shows the coarsely osseous [*i.e.*, cartilaginous] posterior prolongation of the rami, which appear to be terminated in articular processes much in the same manner as occurs in the modern Cestracion. The two nodes *a*, *a* [Fig. 4] are apparently the anterior prolongation of the rami for the support of the

dental plates in that portion of the mouth. And of these anterior teeth I believe we have specimens — a very small, narrow, enrolled form — much resembling the 'second' tooth of *C. contortus*.

"The genus Trigonodus of Newberry will have to be abandoned, it being identical with his Sandalodus. The described forms of the latter probably represent the superior dentition.

"Very respectfully,

"O. St. J."

[NOTE. — It is evident from St. John's pen-and-ink sketch, reproduced in Fig. 3, that his specimens of Edestus belong to *E. minor* N. and W., instead of to *E. vorax* Leidy. The confusion probably arose from the fact that Leidy's name is inadvertently applied to the type of *E. minor* by Newberry and Worthen in their explanation of Plate I of the fourth volume of the *Illinois Palæontology*, an error which was subsequently corrected. The type specimen of *E. vorax* is now preserved in the Museum of the Academy of Natural Sciences of Philadelphia; that of *E. minor* in the Cabinet of Amherst College; and that of *E. giganteus*, which is scarcely distinct from *E. vorax*, in the Columbia College Museum. The location of the type specimen of *E. heinrichi* has been ascertained to be in the State University at Urbana, Illinois.

The depressions on either side of the median projection at *a*, in Fig. 3, are not marks of contact with an adjoining denticle, as supposed by St. John, but are plainly channelings corresponding to the buttressed condition of the crown in *Campodus variabilis* (N. and W.). In fact, a comparison of the symphysial series of the latter with the type of *Edestus minor* proves that the coronal apices of the two forms are surprisingly alike. The detached segments of Edestus are often pyritiferous, and their decomposition is best arrested by treating them with a film of collodion.

The specimen of Cochliodus referred to in the second paragraph above is figured by St. John and Worthen in Vol. VII of the *Illinois Palæontology*, Pl. viii, Fig. 8 *a*, under the name of *Pœcilodus sancti-ludovici*. There seems to be no sufficient reason, however, for its removal from Cochliodus. The complete dentition of this genus is known in at least one species, *C. latus* Leidy. A magnificent specimen is described by Newberry and Worthen in Vol. II of the same work, in which the two pairs of enrolled dental plates belonging to either side of both upper and lower jaws were found in natural association with the anterior series, the latter having the form of "Helodus" teeth. The symphysial series of the same species has been described by Newberry (*Ann. N. Y. Acad. Nat. Sci.*, Vol. xvi, p. 301, Pl. xxiv, Fig. 24) under the name of *Helodus coxanus*. In *C. contortus* the anterior and symphysial series have not yet been definitely recognized as such.]

CAMBRIDGE, MASS.

THE MARSH OR RICE-FIELD MICE OF THE EASTERN UNITED STATES.

S. N. RHOADS.

THE status of the rice-field mice (Oryzomys) found in the marshes of the Atlantic coast from Delaware Bay to the Gulf of Mexico has been of uncertain fixity since our first knowledge of their existence in 1837.

In that year a certain Rev. Dr. Harlan of the Academy of Natural Sciences of Philadelphia is stated by the Rev. John Bachman to have used the skull of one of these mice, sent by him for identification to the Academy, as the basis of the first description of the species, published in *Silliman's Journal.* The name there given was *Mus palustris*, and the professed type a specimen in the Academy's collection labeled as coming from "Fast Land," near Salem, N. J. Until recently no other specimens had been secured in New Jersey, and naturalists had so far concluded that the animal was never found there that Mr. Outram Bangs, in a recent paper on the mammals of Florida and Georgia (*Proc. Bost. Soc. Nat. Hist.*, p. 188, 1898), decided to ignore Harlan's statement as to the type locality and refer it to South Carolina, whence the Bachman specimens were procured. But recent investigations, based on the chance rediscovery of this interesting mouse in the coast marshes of Cumberland County, N. J., as announced two years ago by Mr. Witmer Stone, have enabled the writer to secure a sufficient series of specimens of Harlan's typical *O. palustris* to settle some points in this controversy, as indicated in the following brief synopsis.

1. Harlan's marsh mouse, *Oryzomys palustris* (Harlan).

1836 *Mus palustris* Harlan. *Silliman's Amer. Journ. Sci.* Vol. xxxi, p. 386.

Type locality: "Fast Land" (a term having no meaning to present inhabitants except as applied to upland, or land not needing reclamation from tides), near Salem, N. J.

Geographic distribution (of *palustris*, typicus): Southern New Jersey to northeastern South Carolina.

Habitat: Tide marshes of the coast, inland to the limits of brackish water. Wintering in muskrat houses in New Jersey.

Description of species: Size, smallest of the Atlantic coast group. Skull, relatively large and massive. Colors, above grayish black with pale tawny or ashy suffusion. Underparts wholly grayish white. Fur dense and soft. Average measurements of ten old adults from New Jersey and North Carolina: total length, 237 mm.; tail vertebræ, 108 mm.; hind foot, 29 mm.; ear from crown, 12 mm. Skulls of two old males, total length (basilar, of Hensel), 37 mm.; zygomatic width, 18 mm.

2. Bachman's marsh or rice mouse, *Oryzomys palustris oryzivorus* (Bachman).

1853 *Arvicola oryzivora* Bachman. *Quad. N. Amer.* Vol. iii. p. 214.

1893 *Oryzomys palustris natator* Chapman. *Bull. Amer. Mus. Nat. Hist.* Vol. v, pp. 43–48.

1894 *Oryzomys palustris texensis* Allen. *Bull. Amer. Mus. Nat. Hist.* Vol. vi, pp. 177–179.

Type locality: Southeastern South Carolina, between Charleston and Savannah, Ga.

Geographic distribution: Northeastern South Carolina to Orange and Citrus Counties, Florida, Gulf coast to southern Texas.

Habitat: Same as *palustris*, but penetrating farther inland to fresh water.

Description of species: Compared with *palustris* of New Jersey and northern North Carolina (Bertie County) the differences of Georgia and north Florida specimens, alike typical of *oryzivorus* and *natator*, are too slight to allow of the recognition of both the latter-named races. In fact, no palpable departure from *palustris* is manifest until north Florida specimens are examined. As the *natator* form is thus synonymous from an anatomic and zoögeographic standpoint with Bachman's type, I am forced to so consider it in this review.

Oryzivorus, as thus restricted, may be distinguished from *palustris* by somewhat larger size, a relatively much lengthened tail, and a narrower skull. It is a more slender, elongate animal. The colors of upper parts are browner (less gray) than *palustris*, the subapical third of the hairs of back and sides being pale ochraceous brown instead of pale tawny. The buffy shade invades the underparts and gives a slightly soiled wash thereto even on breast and belly, as contrasted with the uniform clear ashy white of *palustris*. Average measurements of three adults from St. Mary's, Ga.: total length, 255 mm.; tail vertebræ, 118 mm.; hind foot, 30 mm.; ear from crown, 15 mm. Of five males from Gainesville, Fla. (from type locality of *natator*, *fide* Chapman): total length, 286 mm.; tail vertebræ, 136 mm.; hind foot, 33 mm.

It will be seen by above figures that the difference in length consists chiefly in the great *relative* lengthening of the *tail*, the body being not

much larger than in *palustris*. In the specimens from Georgia sent me by Mr. Bangs the largest male skull measures only 26 mm. in basilar length by 17 mm. in zygomatic breadth, though the specimen from which this skull was taken is 20 mm. longer than average *palustris*. This illustrates the tendency of the southern animal to elongate in body without corresponding increase in size and caliber.

3. Bangs' marsh mouse, *Oryzomys palustris coloratus* Bangs.

1898 *Oryzomys palustris coloratus* Bangs. *Proc. Bost. Soc. Nat. Hist.* Vol. xxviii, p. 189.

1901 *Oryzomys natator floridanus* Merriam. *Proc. Wash. Acad. Sci.* Vol. iii, p. 277. (Monroe County, Fla.)

Type locality: Cape Sable, Florida.

Geographic distribution: Tropical life zone of southern Florida, south of Caloosahatchee River and Lake Worth.

Habitat: Not given; probably similar to that of its allies.

Description of species: From Bangs: "Upper parts rich, reddish brown, about between hazel and ferruginous. . . . Under parts white, often suffused with cinnamon. . . . Skull similar to that of *O. palustris natator*, but slightly larger."

Mr. Bangs gives much stress to cranial differences between *coloratus* and "*natator*" = *oryzivorus* and *palustris*, some of which are rather exaggerated, and that of the greater size of the supraorbital bead in *oryzivorus* is not held out by my New Jersey series. He admits the greater slenderness of the skull in southern examples. Consonant with this I find the supraorbital bead to be no more pronounced in these, if anything less heavy than in Georgia examples. Measurements (*fide* Bangs): total length of three adult males, 301 mm.; tail vertebræ, 142 mm.; hind foot, 34.93 mm.

No cranial measurements are given by Mr. Bangs. I include Dr. Merriam's *O. natator floridanus* as a synonym. He seems to have omitted *coloratus* entirely in his recent synopsis. The small size of *floridanus* given by Merriam is puzzling.

In conclusion I may acknowledge my indebtedness to Mr. Outram Bangs for loan of specimens of Oryzomys from South Carolina and Georgia.

AUDUBON, CAMDEN COUNTY, N. J.,
April 14, 1902.

NOTES AND LITERATURE

GENERAL BIOLOGY

Iron and Living Matter.[1] — The title together with the first paragraph of the preface gives a fairly correct idea of the contents of this book. A somewhat free translation of the paragraph referred to is as follows: In the course of my bacteriological and morphological studies I, like so many other observers, felt myself simply overpowered with the infinite variety of the vital phenomena and felt an almost irresistible necessity to gather all these phenomena together under some one fundamental principle. In the course of my attempts to find such a principle I came finally to the conclusion that all vital phenomena are due in the last instance to the oxidation of the iron of living matter.

One scarcely feels like taking the author's discussions of the vital phenomena and their causes seriously because they seem so much more like the dreamy wanderings of an imaginative but untrained mind than like a scientific presentation of a coherent set of facts. It is not clear just why or how the author came to decide upon the oxidation of iron as being the one fundamental process back of the life phenomena. He states in the preface that what helped more than anything else to fix this view in his mind was the fact that he had succeeded in explaining by means of it all the enzyme reactions. Indeed the only *experimental* work recorded in the book is that which is intended to prove that the characteristic enzyme reactions are nothing more or less than the effects of oxidations and reductions of the iron which they are supposed to contain.

The experimental work which is supposed to prove this surprising result consists simply of qualitative tests for iron and phosphoric acid in Merck's commercial enzyme preparations! The author does not seem to understand that the occurrence of traces of iron and phosphorus in commercial enzyme preparations may be only impurities and not a part of the active enzyme, nor does he seem to know

[1] Sacharoff, U. *Das Eisen als das thätige Prinzip der Enzyme und der lebendigen Substanz.* Translated into German by Dr. M. Rechtsamer in Odessa. Jena, Fischer, 1902. 8vo, 83 pp., 2 pls.

that enzymes have been the subject of considerable careful investigation during the past fifteen years and that their nucleoproteid nature which he has just "discovered" is now in fact being given up by the men who are most prominent in the chemistry of the enzymes. Only a few months ago Pekelharing prepared a pepsin which contained no phosphorus; this pepsin still contained a minute trace of iron, as shown by qualitative tests, but it was too small to be determined quantitatively and Pekelharing paid no further attention to it. There is no reason for supposing that Pekelharing could not purify this pepsin still further and thus get rid of the last traces of iron, as he has already removed the last traces of phosphorus, should there be any sufficient object in his doing so.

Since the only experimental evidence cited by the author is thus meaningless there is scarcely any point in following him in a review of this kind through other subjects, such as synthesis of living matter, growth, cell division, reproduction, muscle contraction, the activity of the sense organs, and the chemical processes of the central nervous system. The discussions seem all like the products of a wandering mind whose scientific bearings have been completely lost.

It seems surprising that a firm like that of Gustav Fischer at Jena could have been induced to publish a work of this kind.

O. F.

A New Laboratory Manual of Biology. — The teacher of biology is confronted not only with the problems of his own science, but with those of how best to teach it, and a laboratory manual is a provisional answer to many questions of the second kind. From this standpoint Hargitt's[1] *Outlines* will be of much service to teachers. It abandons the older method of beginning with the simplest representatives of animals and plants which are at the same time least familiar and most difficult of study, and adopts the more recent practice of introducing the subject by well-known types, in this instance the frog and the fern. Then follow exercises on the animal and the vegetable cell, and finally a series of type animals and plants ranging from hydra and the molds to the grasshopper and flowering plants. The mingling of plants and animals in the latter part of the work, though a time-honored practice, destroys the unity which the plant and the animal kingdom ought to show and substitutes nothing of special value for it. The text, which is for the most part clear, is

[1] Hargitt, C. W. *Outlines of General Biology*. C. W. Bardeen, Syracuse, N.Y. 164 pp.

unaccompanied by figures, thus throwing the student more completely on his own resources. Here and there it is perhaps too descriptive, as, for instance, on page 74, where the form of the jellyfish might have been left for the student to make out for himself. Occasionally terms could be improved. Thus, on page 19, in the account of the external apertures of the frog, *anus* is used for *cloacal opening;* and on page 98 the plates of the starfish are described as *bony* instead of *calcareous*. Except for the wrong font of *s*'s on page 38, the proof reader's work seems to have been done with much care. These defects, however, are insignificant compared with the good qualities of the book, which will undoubtedly find its way to many laboratories where plants and animals are dealt with in a single course.

ZOÖLOGY.

Gegenbaur's Comparative Anatomy of Vertebrates.[1] — The second and concluding volume of this masterly work deals with the digestive and respiratory organs, the organs of circulation, and the urogenital system. The present volume is only a little over two-thirds the size of the first one, and its real subject-matter is still further restricted, in that about one-fifth of its 700 pages is given up to an index of some 20,000 entries, covering both volumes. There are 354 text illustrations. One impression made by the perusal of this volume, as compared with the first, is some lack of completeness. Thus, in the section on the pancreas, though the ducts of Wirsung and of Santorini are described, no exact statement is made as to their relations to the anlages of the gland, and the interesting and important phases presented by them in different mammals is passed over without comment. The lungless condition of many salamanders is only briefly noticed (p. 302). The description of the arterial system is very fragmentary. Almost no mention is made of the coronary arteries, whose conditions in the fishes and in the higher vertebrates present many important modifications. The exact comparison of the aortic arches of the amniota with those of fishes is nowhere very clearly brought forward. Although the relations of the azygos and hemiazygos veins of mammals to

[1] Gegenbaur, C. *Vergleichende Anatomie der Wirbelthiere.* Bd. ii. Leipzig, W. Engelmann, 1901. viii + 696 pp.

the post-cardinal veins of the lower vertebrates is sketched, the instructive variations which these veins show is not even alluded to. Thus, in many places the second volume shows deficiencies where, from the completeness of the first, one would expect to find an ample and well-balanced account. As in the first volume, so in the second there is a strong disinclination to accept the results of embryology. Though this is in some respects an advantage, for in the last twenty years embryological evidence has certainly been given much more weight than it should have had, still its almost complete exclusion is by no means a wise course. The account of the origin of the complex teeth of mammals and the question of the number of generations of teeth in this group, lose much by the omission of embryological facts. So, too, the discussion of the relations of the pronephros to the mesonephros is left in a very unsatisfactory form because of the absence of embryological data. While embryology may have been too exclusively followed by many, its results are too important to be lightly cast aside. Notwithstanding the defects that have just been pointed out, the volume before us and its companion certainly represent the high-water mark among modern comparative anatomies of the vertebrates, and the author is to be congratulated on his good fortune in having completed a book that will bear comparison not only with the best of contemporary work but with the best that has gone before. P.

Animal Life in the Deep-Sea. — Professor Seeliger's[1] pamphlet of fifty pages presents a very readable popular account of the animal life of the deep sea. After a brief historical résumé of the growth of deep-sea investigations, the effect of the environment on the animals is considered. The icy temperature of the deeper waters is contrasted with the variable temperature of the surface. The influence of the enormous water pressure is well illustrated by comparison with that of atmospheric pressure. The presence of free oxygen and of carbon dioxide and the influence of the latter on skeleton building in deep waters are discussed. Finally, the absence of sunlight and its relation to the sense organs, luminous organs and food supply of the deep-sea animals is dealt with at some length. The account, though brief, is carefully compiled, and is followed by an excellent series of note references, in which some of the questions brought forward in the text are more fully considered.

[1] Seeliger, O. *Tierleben der Tiefsee.* Leipzig, W. Engelmann, 1901. 49 pp., 1 Tafel.

Direction of Hair. — Students of general biology will be interested in Kidd's[1] studies on the direction of hair as evidence of the inheritance of an acquired character. The author points out that the hair slope of an individual may be modified during life. The hair streams of mammals are disposed in lines of least resistance, and yet are of so little importance to the animal that they cannot be regarded as produced by selection, — natural, sexual, or germinal. As they have arisen through the mechanical influence of the environment and have been handed on from generation to generation, they afford what the author believes to be a good example of the inheritance of acquired characters.

Alcyonaria of the Azores.[2] — The explorations of the *Hirondelle* about the Azores, the Gulf of Gascogne, and Terre Neuve brought to light thirty-eight species, of which nineteen were new. The Alcyonaria from the Azores are increased from six to twenty-nine, of which twelve were new, and the total for the Atlantic between Madeira and the arctic circle reaches one hundred and sixty-six. Six species found at the Azores have been taken in the West Indies or off the coasts of North America, which is about the same proportion of American species found among the mollusks of the Azores in the collections of the *Hirondelle*. The American species are all from depths below 500 meters, while those peculiar to the eastern parts of the Atlantic come mainly from levels above 400 meters. The abyssal forms are thus the only ones common to America and the Azores. The occurrence near the Azores of several species from the Mediterranean serves to emphasize still further the dependency of its fauna upon that of the Atlantic. The genus Calypterinus is rejected and its species transferred to Stachyodes, the supposed generic distinctions being due to a pathological condition caused by the presence of an annelid, one of the Eunicidæ, in a furrow of the trunk. C. A. K.

Corals of the Pacific.[3] — The author finds that the corals of Hawaii and Laysan are principally Porites, Pollicipora, and Montipora. The

[1] Kidd, W. *Use-Inheritance illustrated by the Direction of Hair on the Bodies of Animals*. London, A. and C. Black, 1901. 47 pp.

[2] Studer, Th. Alcyonaires provenant des campagnes de l'*Hirondelle*, 1886–1888, *Result. des campagn. scient. Albert de Monaco*, fasc. 20, 1901. 4to, 64 pp., 11 pls.

[3] Studer, Th. Ergebnisse einer Reise nach dem Pacific (Schauinsland, 1896–1897), Madreporarier von Samoa, den Sandwich-Inseln und Laysan, *Zool. Jahrb.*, Abth. f. Syst., Bd. xiv (1901), pp. 388–428, Taf. XXV–XXXI.

Madrepores and Astræidæ common in more southerly waters and carried northward in the eastern Pacific by the Japan current do not characterize these northerly reefs of Hawaii and Laysan. The reef-building corals of this region show more affinity to those of lower California and the Mexican coast, to the Panamic fauna, due in the author's opinion to the weak westerly current in which the islands in question lie. This not only tends to establish Panamic influences here but prevents the access of the southern fauna, *e.g.*, the Madrepores.

C. A. K.

The Lepidopterous Genus Depressaria. — The tineid moths of North America, owing to their great number, small size, and the difficulty of preserving them in good condition, have not received the attention they deserve. Yet there are few groups which offer such good opportunities for original research, our country being full of undescribed forms, many of interesting habits, remarkable form, or exquisite colors; while not a few are destructive to cultivated plants. Under these circumstances we rejoice to find that Mr. August Busck, of the Department of Agriculture, has taken up the study of these insects with remarkable energy and enthusiasm. Our pleasure in Mr. Busck's studies is the greater because the material he works upon is in our National Museum, where it can always be found and examined by the student. It is to be hoped that collectors in all parts of the country will contribute material and biological notes, all of which will be carefully acknowledged by Mr. Busck in publication, if we may judge of his methods by the paper before us. This paper (*Proc. U. S. National Museum*, Vol. XXIV, pp. 731–749) is a revision of the North American species of the genus Depressaria, of which thirty-nine are recognized as valid. It is not necessary in this place to enter upon any detailed discussion of the paper, but we may be permitted to point out that two of the specific names are wrongly spelled, owing to the erroneous spelling (so common among entomologists !) of the food plants from which the names are derived. *Depressaria psoraliella* Wlsm. (p. 740) should be *D. psoraleella*, the plant being Psoralea. *D. senicionella* Busck (p. 742) should be *D. senecionella*, the plant being Senecio. The food plant of *D. arnicella*, from Mt. Shasta, is said to be *A. angustifolia* (*i.e.*, *A. alpina*); but it seems that this species does not occur on Mt. Shasta, and the plant was more likely *A. longifolia* Eaton.

T. D. A. C.

BOTANY.

A University Text-Book of Botany.[1] — Botany as taught to-day differs from the same subject as taught when many of the older teachers of to-day were students, more in its many-sidedness than in any other respect, — a result largely due to the publication and use of Sachs' text-book in the seventies, and of the translations, adaptations, and abridgments of that book that quickly followed its appearance. Since then numerous and in some cases excellent laboratory and reference books, prepared for elementary class or laboratory use or for students of special branches of the science, have been brought out, but no distinctly original comprehensive book of large size has appeared from an American author before this work by Professor Campbell.

In his preface the author clearly states his purpose to have been the preparation of a reference book, and not a laboratory manual, presenting in as compact a form as possible an outline of the essentials of modern botany and drawing its illustrations as far as possible from American material. A large part of the figures are original; and while, of necessity, anything like full references to the enormous literature of even the last few years have been impossible, each subject is provided with a short bibliography, opening the way to other references.

The book consists of fifteen chapters, headed: Introduction, The Plant Body, The Plant Cell, Classification, The Algæ, Fungi, The Archegoniatæ, Pteridophyta (two chapters), Spermatophyta (three chapters), Physiology, Relation to Environment, and Geological and Geographical Distribution. The treatment is interesting and direct, yet conservative in debatable matters, and half-tone plates scattered through the text, representing types of vegetation and plant societies, add much to the effectiveness of the ample illustration. W. T.

The Cyclopedia of American Horticulture.[2] — In the summer of 1900 the first volume of this large and comprehensive work was put

[1] Campbell, D. H. *A University Text-Book of Botany.* New York, The Macmillan Company, 1902. xv + 579 pp., 15 pls., 493 figs.

[2] Bailey, L. H., and Miller, W. *Cyclopedia of American Horticulture.* Comprising suggestions for cultivation of horticultural plants, descriptions of the species of fruits, vegetables, flowers, and ornamental plants sold in the United States and Canada, together with geographical and biographical sketches. Illustrated with over 2000 original engravings. In four volumes. New York, The Macmillan Company, 1900–1902. $20.

in the hands of subscribers, and the early spring of 1902 sees the concluding volume in print. What has been said earlier in the *Naturalist* about the quality of the first three volumes applies equally well to the one now issued. Whether the work be consulted by the gardener for cultural methods, by the amateur for the names of cultivated plants, or by the schoolmaster for information as to the horticultural resources and possibilities of a given state or territory, it will be found to offer a ready answer to most questions and to indicate how the more obscure ones may be answered by one having the patience to follow them up. Throughout the *Cyclopedia* the personality of its editor is manifest, although very many of the articles have been written by others; and perhaps the most interesting reading in it is the introduction to the fourth volume, in which, from his own pen, we learn how the work was conceived, planned, and executed. The *Cyclopedia* is a notable piece of book making, and it is gratifying to know that the editor hopes, by means of annual supplements, to round it out with analytical keys for the determination of genera, — which in the body of the work are alphabetically arranged, — an extended bibliography, and the current chronicles of horticultural change.

W. T.

Notes. — In the *Ottawa Naturalist* for April Professor Greene describes five new species of Ranunculus, from various parts of the United States and Canada.

In the *Botanical Gazette* for February Professor Sargent publishes a fourth paper on "New or Little-Known North American Trees," among which are several notable species of Cratægus and one of Prunus.

Prunus virginiana and *P. serotina*, as cultivated in France, are contrasted by Guinier in Nos. 1–2 of the current volume of the *Bulletin de la Société Botanique de France.*

The Lespedezas of Missouri are reviewed by Mackenzie and Bush in No. 2 of the current volume of *Transactions of the Academy of Science* of St. Louis.

Lieferungen 4, 5 of Schumann's "Blühende Kakteen" have appeared.

A voluminous study of *Cirsium arvense*, by Lund and Rostrup, with French abstract, has been published as Vol. X, No. 3, of the *Mémoires de l'Académie Royale des Sciences et des Lettres de Danemark.*

Professor Branner, who paid particular attention to palms while connected with the geological survey of Brazil, twenty or more years ago, and who then published an exhaustive account of the structure of the palm stem, has once more taken up his notes, and in the *Popular Science Monthly* for March gives a well-written illustrated account of the ecological and economic characteristics of the Brazilian palms.

No. 22 of the current series of "Contributions from the Gray Herbarium of Harvard University," constituting Vol. XXXVII, No. 17, of the *Proceedings of the American Academy of Arts and Sciences*, is by Mr. Fernald and deals with species of Carex.

A memoir on *Ustilago reiliana*, by Mottareale, has been separately issued from Vol. IV, fascicle 2, of the *Annali della R. Scuola Superiore d'Agricolture in Portici.*

Hefte 7, 8 of Engler's *Das Pflanzenreich* are devoted respectively to Naiadaceæ (by Rendle) and Aceraceæ (by Pax).

The fourth part, concluding Vol. I, and the second part of Vol. II, of the British Museum *Catalogue of the African Plants collected by Dr. Friederich Welwitsch in 1853–61* have been distributed by the trustees of the Museum.

Vol. III, Part III, of J. Medley Wood's *Natal Plants*, comprising Pls. CCLI to CCLXXV, inclusive, has recently been issued.

Vol. VII of the "Flore de France," by Rouy and Foucaud (continued by Rouy and Camus), constitutes the 1900 volume of the *Annales de l'Académie de La Rochelle*, recently issued. It extends from Rosaceæ to Cornaceæ.

Another of Dr. von Schrenk's important contributions to the economic study of mycology constitutes *Bulletin No. 14* of the Bureau of Plant Industry of the U. S. Department of Agriculture, and deals with the decay of timber and methods of preventing it. In addition to the results of his own study, the author includes a summary of the preventive results reached in Europe. As in his earlier papers, illustrations are both full and good.

A detailed account of the raising and manufacture of vanilla, by Lecomte and Chalot, is published from the press of Naud of Paris.

A paper on the Caoutchouc-yielding Landolphiaceæ, by Hua and Chevalier, is issued by Challamel of Paris.

If Mr. Wells's artist could have illustrated his hypothetical lunar landscapes from the vegetation of the central African "mountains of the moon," as figured by J. E. S. Moore in some cuts reproduced in *Nature* of January 23, he would have gained rather than lost in the uniqueness of the effect.

In *Forest Leaves* for February Professor Rothrock figures habit and bark of *Pyrus coronaria.*

An illustrated paper on Ochnaceæ, by Barteletti, is published in fascicle 4–6 of *Malpighia.*

Professor Greene publishes three new species of Senecio from British Columbia in the *Ottawa Naturalist* for February.

Liatris pycnostachya, as a garden plant, is illustrated in *Die Gartenwelt* of January 11.

The orchids of eastern Asia, as represented in the herbarium of the Muséum d'Histoire Naturelle, form the subject of an illustrated paper by Finet, in the *Revue générale de botanique* of December 15.

The conclusion of Spegazzini's "Stipeæ Platenses" constitutes No. 22, Vol. IV, of the *Anales del Museo Nacional de Montevideo.*

Fusicladium dendriticum is the subject of *Bulletin No. 67* of the Illinois Experiment Station, by Mr. Clinton. It is illustrated by a number of reproductions of photographs, and eleven pages are given to a full bibliography, — a feature as useful as it is unusual.

In the *Botanical Magazine* of Tokyo, No. 178, Vyeda has an illustrated paper on the "Benikoji fungus" of Formosa, — used in the production of a red fermented rice beverage.

Dr. Peglion publishes an article on the cereal Peronospora (*Sclerospora graminicola*) in *L'Italia Agricola* of January 15.

"The Algæ of Jamaica" is the title of a paper by F. S. Collins, published as Vol. XXXVII, No. 9, of the *Proceedings of the American Academy of Arts and Sciences.*

The life history of *Oscillaria prolifica* is sketched by Isabel F. Hyams and Ellen H. Richards in the *Technology Quarterly* of December.

An ecological study of the heath formations of northern Germany, by Graebner, constitutes Vol. V of Engler and Drude's *Die Vegetation der Erde*, and is the first of a series of volumes that are to deal with the plant formations of middle Europe. Though Germans

commonly use the word *Heide* in the sense of a wood, Graebner agrees with classic English usage in employing it for the open bushy formations characterized by Erica, Calluna, Empetrum, Juniper, etc.

Professor Selby, in the *Bulletin of the Torrey Botanical Club* for December, records another series of experiments with seeds subjected to the low temperature of liquid air, with the customary result that their viability appears not to be affected by even a forty-eight hours' sojourn at a temperature of $-190°$ C.

Dr. Goodale has a short note in the *American Journal of Science* for February on the memorial greenhouses at the Harvard Botanic Gardens and some of the physiological work being done in them.

The effects of water and of certain aqueous solutions on foliage are discussed by J. B. Dandeno in a lengthy and well-illustrated paper, reprinted from Vol. VII of the *Transactions of the Canadian Institute.*

The mapping of botanical data is discussed by Blanc in the *Bulletin de l'Herbier Boissier* of December 31.

A practical little handbook of greenhouse methods, that should be in possession of every "nature-study" teacher, is Green and Mackintosh's Outline of greenhouse laboratory work, issued as *Class Bulletin No. 12* of the Experiment Station of the University of Minnesota.

A paper by Mr. Chesnut on plants used by the Indians of Mendocino County, Cal., constitutes No. 3 of Vol. VII of *Contributions from the U. S. National Herbarium*, and contains numerous illustrations.

Lieferung VI of the new edition of Wiesner's *Rohstoffe des Pflanzenreiches*, issued in December, begins a consideration of economic woods and contains numerous illustrations of structural detail.

Vegetable powders and the means of knowing their composition by aid of the microscope are being treated by Greenish and Collin in current numbers of the *Pharmaceutical Journal.*

M. de Wildeman has recently distributed an account of late-producing Apocynaceæ, collected in the Congo country by Gentil.

The cause of white-topped meadow grasses in Finland is discussed by Reuter in Vol. XIX of *Acta societatis pro fauna et flora fennica*, and a bibliography of the subject is given.

Dr. White publishes a note on the use of *Solanum heterodoxum* in Mexico for the curdling of milk, in *Science* of December 13.

A long list of decorative plants hardy in South Dakota is given by Mr. Hansen in *Bulletin No. 72* of the experiment station located at Brookings.

An interesting illustrated article on rattan and its preparation for the market, by Preyer, is published in *Der Tropenpflanzer* for January.

In *Bulletin No. 6*, dealing with Capsicums, by Mr. Tracy, the Bureau of Plant Industry of the U. S. Department of Agriculture begins the publication of a series of catalogues of the trade names of American vegetables.

In the concluding fascicle of Vol. XIV of the eighth series of the *Annales des sciences naturelles, botanique*, M. Van Tieghem sums up the results of his studies on the ovule as a basis of classification in the flowering plants, giving at the end a résumé of the vegetable kingdom classified on this basis.

Dalla Torre and Harms' *Genera Siphonojamarum* in the fourth fascicle reaches the genus Cochleanthera of the Guttiferæ.

Engler and Prantl's *Die natürlichen Pflanzenfamilien* in Lieferung 211 reaches Isoetaceæ among the pteridophytes and in Lieferung 212, Pottiaceæ among the bryophytes.

An account of the dates at which the parts of Elliott's *Botany of South Carolina and Georgia* were issued is contributed to the December *Bulletin of the Torrey Botanical Club* by Barnhart.

The double fascicles 14–15 and 16–17 of Ascherson and Graebner's *Synopsis der Mitteleuropäischen Flora* deal respectively with Rosaceæ (in part) and Gramineæ (in part).

In Coste's *Flore descriptive et illustrée de la France*, the second volume of which is now in course of publication by Klincksieck of Paris, the description of each species is accompanied by an excellent small cut, showing habit and often essential detail.

An anatomical study of Hippocrateaceæ, connected with the occurrence of caoutchouc in that family, by Fritsch, occupies Heft 5 of Vol. XI of the *Beihefte zum botanischen Centralblatt.*

The aid afforded by calcium oxalate crystals in the identification of vegetable drugs is the subject of a paper by Kraemer in the *Journal of Pharmacology* for December.

The development, structure, and properties of the epidermis of certain dicotyledonous plants which persist for several years, forms the subject of a paper by Damm in Vol. XI, Heft 4, of the *Beihefte zum botanischen Centralblatt.*

Professor Heckel publishes, through the house of A. Challamel of Paris, a valuable paper on "Les graines grasses . . . des colonies françaises."

Part VII of Wiesner's *Rohstoffe des Pflanzenreiches*, appearing from the press of Wilhelm Engelmann of Leipzig, is devoted to fibers.

The pollination of *Solanum rostratum* and *Cassia chamæcrista*, both of which produce right- and left-handed flowers on the same plant, has been reinvestigated by Harris and Kuchs, whose paper is published in the February number of the *Kansas University Science Bulletin.* The earlier conclusions of Todd are not confirmed.

A paper by Haberlandt, entitled "Sinnesorgane im Pflanzenreich," issued from the Engelmann press of Leipzig, deals with irritable stamens, pistils, foliage leaves, insect traps, and tendrils.

A biographic sketch of Schimper, by Schenck, with portrait, has been separately printed from the *Berichte der deutschen botanischen Gesellschaft* for 1901.

A Eulogy of Unger, delivered in connection with the unveiling of the Unger bust at the Vienna University last July, has recently been distributed by Professor Wiesner, from the *Verhandlungen der k.k. zool.-bot. Gesellschaft in Wien.*

QUARTERLY RECORD OF GIFTS, APPOINTMENTS, RETIREMENTS, AND DEATHS.

EDUCATIONAL GIFTS.

Albion College, $21,000, from Gov. A. T. Bliss.

Adelphi College, Brooklyn, $125,000, from John D. Rockefeller; $125,000 from other donors.

Amherst College, $25,000, for the library, from Col. Mason W. Tyler; $65,000, from alumni and friends, for an observatory.

Bryn Mawr College, gifts amounting to $256,000, thus securing the conditional gift of $250,000 from John D. Rockefeller.

Columbia University, $50,000, from Mrs. Lena Currier.

Cornell University, $250,000, from John D. Rockefeller; $250,000, from other sources.

Dartmouth College, $32,500, by the will of F. W. Daniels.

Hamilton College, $5000, by the will of Prof. Anson Judd Upson.

Lick Observatory, $2500, from Mrs. Phœbe A. Hearst.

Massachusetts Institute of Technology, $5000 a year, for three years, for work in sanitary science.

Northwestern University, about $200,000, by the will of James F. Robinson.

Pennsylvania State College, $100,000, from Andrew Carnegie; $60,000, from Mr. and Mrs. C. M. Schwab; $20,000, from James G. White.

Radcliffe College, $5000, by the will of Mrs. Sarah A. Rand.

Rutgers College, $20,000, from F. M. and Ralph Vorhees.

Swarthmore College, a conditional gift of $100,000, from Isaac H. Clothier; $300,000, from other sources.

Smith College, $100,000, from various sources, securing the Rockefeller gift of the same amount.

University of California, $20,000, from Mrs. Phœbe Hearst; $5000, from Henry Weinstock; $8000, from Dr. M. Herzstein; $50,000, from D. O. Mills; $30,000, from other sources.

University of Pennsylvania, $300,000, from Joseph Wharton, for the school of finance; $100,000, for new buildings, from an anonymous donor.

University of Vermont, $6000, from Dr. Seward Webb, for the purchase of the Pringle herbarium.

Union College, $40,000, from Andrew Carnegie; $125,000, by compromise, from the estate of Thomas Armstrong.

Vassar College, a library building, from an anonymous donor.

Wells College, $50,000, from Henry A. Morgan; $25,000, from N. L. Zabriskie.

Wesleyan University, $75,000, from Charles Scott, Sr. and Jr., for a physical laboratory; $75,000, from an anonymous donor.

Western Reserve University, $100,000, from A. A. Pope.

Yale University, the residue of the estate of Edward W. Southworth, estimated at $200,000 to $300,000; a chemical building, costing, with the land, $96,000, from Mrs. Thomas G. Bennet; a building for the geological department, from an anonymous donor.

APPOINTMENTS.

Dr. Florentino Ameghino, director of the National Museum of Buenos Aires. — A. P. Anderson, curator of the herbarium of Columbia University. — J. H. Bair, assistant in anthropology in Barnard College. — Dr. F. A. Bather, assistant keeper in the department of geology in the British Museum. — Dr. A. N. Berlesi, assistant professor of plant pathology in the university at Milan. — Dr. Robert S. Breed, professor of biology and geology in Alleghany College. — Jean A. Brodhurst, assistant in botany in Barnard College. — Dr. R. E. Buffington, assistant in histology in Columbia University. — Dr. F. Carara, assistant professor of botany in the university at Catania. — Dr. D. Carazzi, assistant professor of zoölogy in the university at Sassari. — Dr. Adolf Cluss, professor of bacteriology in the university at Halle. — Dr. W. C. Coker, associate professor of botany in the University of North Carolina. — Dr. Carl Erich Correns, professor extraordinary of botany in the university at Leipzig. — Arthur L. Dean, assistant in plant physiology in Yale University. — Dr. R. B. Dixon, instructor in anthropology in Harvard University. — Dr. J. E. Duerden, interim professor of zoölogy in the University of North Carolina. — Dr. B. M. Duggar, professor of botany in the University of Missouri. — Dr. A. Fischer, professor of botany in the university at Basel. — Dr. P. A. Fish, professor of physiology and pharmacology in Cornell University. — Dr. Fournier, professor of geology and mineralogy in the university at Besançon. — Professor F. Gräff, head of the mineralogical institute at Freiburg i. B. — Dr. Caswell Grau, associate in zoölogy in Johns Hopkins University. — Dr. Arthur W. Greeley, assistant professor of zoölogy in Washington University. — Dr. J. Henscher, professor extraordinary of parasitology in the university at Zürich. — Dr. William Hunter of London, government bacteriologist at Hongkong. — Dr. Giuseppe Jatta, docent for zoölogy in the university at Naples. — Dr. E. C. Jeffrey, assistant professor of vegetable morphology in Harvard University. — Herbert Stanley Jevons, lecturer in mineralogy in the University of Sydney, N.S.W. — Dr. B. F. Kingsbury, professor of human physiology in Cornell University. — Dr. Ludwig Koch, honorary professor of botany at Heidelberg. — Dr. Henry B. Kümmel, state geologist of New Jersey. — Ivey F. Lewis, assistant in biology in the University of North Carolina. — Haven Metcalf,

professor of botany in Clemson College. — Dr. P. Mingazzini, professor of zoölogy in the university at Messina. — Dr. F. W. Neger, professor of botany in the forestry school at Eisenach. — Dr. Russell B. Opitz, demonstrator in physiology in Columbia University. — Dr. Charles Palache, assistant professor of mineralogy at Harvard University. — Dr. Florence Peebles, assistant professor of biology in the Woman's College of Baltimore. — C. G. Pringle, keeper of the herbarium of the University of Vermont. — Dr. F. Raffaele, professor of zoölogy in the university at Palermo. — Hugh D. Reed, instructor in vertebrate zoölogy in Cornell University. — L. F. Rettiger, instructor in bacteriology in Yale University. — Ralph W. Richards, instructor in geology in Tufts College. — Dr. H. Ries, assistant professor of geology in Cornell University. — Dr. D. Rosa, professor of zoölogy in the university at Modena. — Dr. Rudolf Rosemann, professor of physiology in the university at Greifswald. — Dr. A. Russo, professor of zoölogy in the university at Catania. — Dr. Florence R. Sabin, assistant in anatomy in Johns Hopkins University. — Dr. D. Saccardo, assistant in the royal institute of plant pathology at Rome. — Camille Sauvageau, professor of botany at Bordeaux. — Dr. Victor Schiffner, professor extraordinary of botany in the university at Munich. — Dr. R. J. Schubert, assistant on the Austrian Geological Survey. — Dr. George B. Shattuck, associate professor of physiographic geology in Johns Hopkins University. — Dr. Yngve Sjöstedt, custodian of the entomological collections at Stockholm. — Dr. Hans Soledever, professor of botany in the university at Erlangen. — Dr. R. M. Strong, interim professor of zoölogy in Haverford College. — Dr. Albert R. Sweetser, professor of biology in the University of Oregon. — Dr. G. B. de Toni, professor of botany in the university at Sassari, Sardinia. — Dr. Karl von Tubeuf, professor of forestry in the university at Munich. — Dr. Frank R. Van Horn, professor of geology at the Case School of Applied Science at Cleveland. — Dr. L. Waager, assistant on the Austrian Geological Survey. — Dr. Adolf Wagner, docent for botany in the university at Innsbruck. — William A. Willard, instructor in zoölogy in the University of Nebraska. — Dr. I. Wendell Williston, head professor of paleontology in the University of Chicago. — Dr. Alfred W. G. Wilson, demonstrator in geology in McGill University. — Dr. E. Zacharias, director of the Hamburg City Institute of Botany. — J. V. Zelizko, assistant in the museum of the Austrian Geological Survey. — Dr. Carl Zimmer, custodian of the zoölogical institute and museum in Breslau. — Professor R. A. Zimmermann, botanist to the biological station at Tanga, German East Africa.

RETIRED.

Dr. Max von Vintschgau from the chair of physiology in the university at Innsbruck.

DEATHS

Sergius Alpheraky, Russian entomologist. — Prof. Ernst von Ballion, entomologist, at Novorossiisk, Russia, Sept. 9, 1901, aged 84. — Dr. C. Berg, director of the National Museum in Buenos Aires, and a well-known zoölogist, January 19. — Dr. Alexander Bittner, head geologist of the Austrian Geological Survey in Vienna, April 1. — Dr. Hans Buchner, professor of bacteriology in the university at Munich, April 5, aged 51. — Stanislaus Clément, zoölogist and former head of the museum at Nîmes, February 7, aged 73. — J. Ottoman Dietz, student of Coleoptera, in New York, December 25. — Henri Filhol, vertebrate paleontologist of the Paris Natural History Museum, April 28, aged 60. — Dr. Friederich Leopold Goltz, professor of physiology in the university at Strassburg, May 4, aged 68. — C. J. Emil Haglund, student of Hemiptera, at Lommaryd, Sweden, Dec. 9, 1901, aged 64. — Emil Holub, African traveler and ornithologist, in Vienna, February 21, aged 55. — Dr. Joseph Kriechbaumer, student of Hymenoptera, in Munich, May 2. — T. J. Léger, professor of botany in the university at Caen, aged 36. — Alonzo Linn, bryologist in Jefferson College, Washington, Pa., Sept. 28, 1901. — Dr. Emil Adolf Lövendal, conservator of the zoölogical museum at Copenhagen, entomologist and skillful engraver on copper, July 6, 1901, aged 62. — J. C. Mausel-Pleydell, zoölogist, in Whatcombe, England, May 3, aged 84. — Carl Nehring, collector, in Piracicaba, Brazil, January 3. — Joseph Nolan, assistant on the geological survey of Ireland, in Dublin, April 19. — W. H. Penning of the geological survey of the United Kingdom, in London, April 20. — Andreas Reischet, naturalist and head of the Linz Museum, aged 55. — Dr. Carlo Riva, instructor in petrography in the university at Pavia, killed by an avalanche on Monte Grigna, June 3. — Baron Friedrich Rosen, professor of mineralogy in the university at Kazan, aged 68. — Dr. Richard Burton Rowe of the U.S. Geological Survey, at Los Angeles, Cal., May 26, aged 30. — Dr. Ferdinand Sommer, formerly professor of anatomy at Greifswald, aged 74. — Baron E. von Tröltsch, archæologist of Würtemburg, June 29, 1901, aged 73.

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